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Timing the Seasonal Cycles of Insects[1]

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Timing the seasonal cycles of insects by the use of accurate data is of primary importance in economic entomology. The concise determination of the time factor forms the basis of life history studies, and often is essential for the application of successful control measures. It seems worth while, therefore, to give attention to studies that might lead to more accurate or more adaptable methods of timing.

It is generally agreed among entomologists that it is desirable to time the activities of insects with reference to phenological events, and it is a rather common practice in publications on the biology and control of fruit pests to give the dates of petal-fall or of the blossom period.

A series of careful records of the life histories of several species of insects covering periods of 5 to 10 years, presents opportunity to make a rather critical study of timing in relation to petal-fall, compared with calendar date.

The life history records under consideration were made at Monmouth, Maine, during the period 1933 to 1942, inclusive. The observations on petal-fall were made in an orchard of McIntosh apple trees at Highmoor Experimental Farm at Monmouth by Dr. Donald Folsom, Plant Pathologist of the Maine Agricultural Experiment Station.

In several respects, the phenomenon of petal-fall serves as an almost ideal date for timing seasonal events. The time of petal-fall is easily observed. It can be determined quite accurately, for the event usually is sharp, clear cut, and lasts for only a brief period. Moreover, the calyx spray is usually applied immediately after petal-fall, so the time is generally observed and often recorded by apple growers, as a matter of routine.

In the present paper, "petal-fall" is used with the commonly accepted definition as the time when 75 to 90 per cent of the petals have dropped from the trees. The time was determined by rather careful observation, but not by detailed counts. Should it become necessary to do so, perhaps more exact methods may be used, and careful counts of the petals made. The time might be given more narrow limits by stating a definite percentage —for example when 50 per cent of the petals have dropped. Possibly observation of the first dropping of the petals, or of the completion of petal-fall also may be useful. The date of petal-fall should be based upon known varieties of apples, and consideration should be given to the relative time of petal-fall in different apple varieties.

The observed dates of petal-fall for a period of 14 years are shown in table 1.

Table 1.—Dates of petal-fall of McIntosh apples at Highmoor Farm, Monmouth, Maine (Records by Donald Folsom).

YEAR	DATE	YEAR	DATE
1930	May 28	1937	May 31
1931	May 28	1938	May 30
1932	May 29	1939	June 6
1933	May 29	1940	June 5
1934	May 31	1941	May 22
1935	June 3	1942	May 21
1936	May 30	1943	June 1

The mean date of petal-fall for the 14-year period is May 29–30.

PROCEDURE.—The data presented include records of the life histories of the apple maggot, *Rhagoletis pomonella*, plum curculio, *Conotrachelus nenuphar*, apple seed chalcid, *Callimome druparum*, and

[1] Presented at the Eastern Branch Program and awarded the Annual Medal of the Eastern Branch of the American Association of Economic Entomologists for the year 1943.

[2] Appreciation should be expressed to Miss Mildred Covell, Technical Assistant, Maine Agricultural Experiment Station, for assistance in the computations involved in this paper; to Fred Kinney, Arnold Pitman, and Alfred Gordon, formerly summer assistants in Entomology, for performing much of the routine work involved.

roundheaded apple tree borer, *Saperda candida*. The life history data are generally based upon daily counts. In most of the work, large numbers of the insects were concentrated in outdoor cages, and the records are fairly comparable from year to year. For the present paper, the records of a series of years were brought together, and, except for the roundheaded borer, the data for each year were converted to percentages to facilitate comparison.

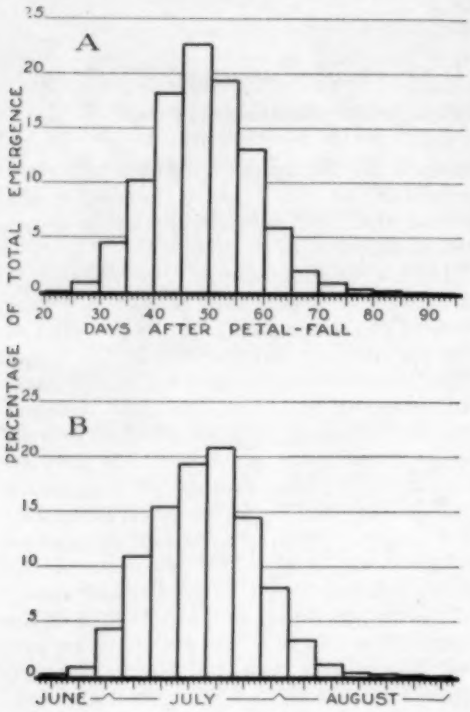

FIG. 1.—Apple maggot—emergence of adult flies. A 10-year average, 1933 to 1942, based on a total of 123291 flies.

In each figure, 1 to 6, A shows the data arranged on the petal-fall scale; B shows the same data arranged on the calendar scale. In the histograms, each bar represents the total percentage during a 5-day period. Unless otherwise stated, petal-fall on scale A coincides with the average date of petal-fall (May 29–30) on scale B, and the 5-day intervals on the two scales coincide.

Summaries based upon the calendar-date scale were made first, then the data were rearranged and summarized on the petal-fall or phenological scale. When one year is considered alone, the data remain unchanged, whether viewed with respect to the calendar scale or on the petal-fall scale. When the records for two or more years are included, however, it becomes necessary to shift the data for each year in order to make the dates of petal-fall for all years coincide. The effect of the shifting of the records of individual years is illustrated in figure 4.

When the time of petal-fall occurs on the same date, in two years their relative positions remain unchanged. When the petal-fall dates are different, shifting becomes necessary to change from one scale to the other, and the greater the difference between the dates of petal-fall, the greater becomes the difference in the relative positions of the data on the two scales.

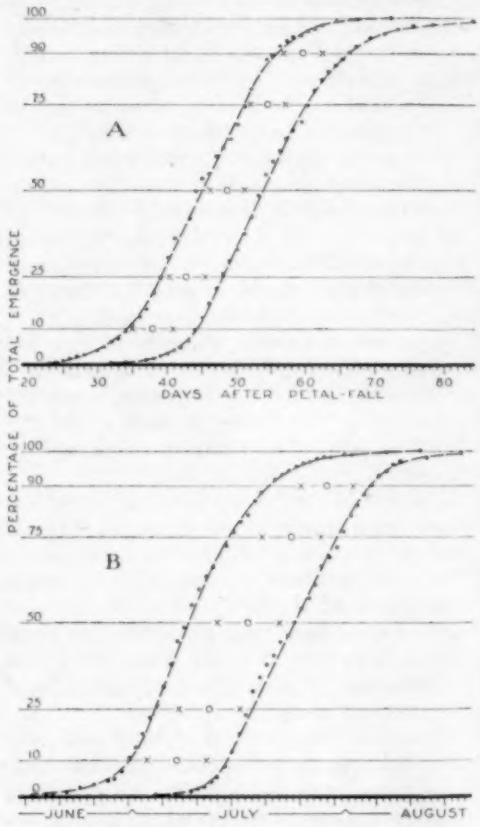

FIG. 2.—Apple maggot—emergence of adults. The data cover a 10-year period, 1933 to 1942, and include a total of 123291 flies. The curves represent, respectively, the earliest and the latest emergence that occurred during the 10 years. The circles mark the mean time of emergence of the percentages indicated. The crosses indicate the standard deviations from the mean dates. To make the data on the two scales coincide, scale A should be moved to the right until 31 days after petal-fall coincides with June 30 on scale B.

It is interesting to notice that the data presented in figures 1 to 6 and tables 1 to 4, include overlapping periods extending from 45 days before petal-fall to 145 days after petal-fall, and from April 16 to October 21.

It seemed somewhat surprising that the transfer from the calendar scale to the petal-fall scale would produce such marked and consistent changes in the data even as long as 80 or 90 days after petal-fall.

Consideration of the data reveals several general tendencies resulting from the change from the calendar date to the phenological scale. On the petal-fall scale, the data tend to be more closely grouped, with less variation between years. Plotted on the petal-fall scale, the data more promptly approach the form of a normal distribution curve. The distribution on the petal-fall scale is characterized by higher peaks, and shorter bases.

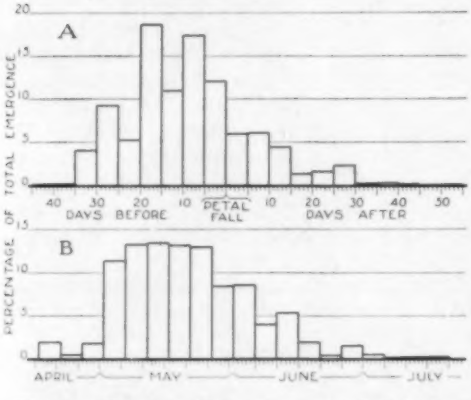

FIG. 3.—Plum curculio—emergence of adults from hibernation. A 7-year average based on a total of 6244 adults. The 5-day periods do not quite coincide on the two scales. "Petal-fall" on scale A, coincides with the average date of petal fall on scale B.

The decrease in variation between years, resulting from the use of the petal-fall scale, is especially well illustrated in figures 2 and 4. The data of the individual years on the petal-fall scale (Fig. 4A) are more closely grouped in contrast to the greater divergence on the calendar scale, figure 4B. The limits of variation that occurred in the 10-year records of fruit fly emergence, are shown in figure 2.

The maximum difference between the earliest and the latest emergence on the calendar scale (Fig. 2B) is approximately 16 days, and on the petal-fall scale (Fig. 2A) the maximum difference is reduced to approximately 9 days. Table 2 shows that the standard deviations from the mean time of emergence of the flies is decidedly less on the petal-fall scale, in comparison with the calendar scale.

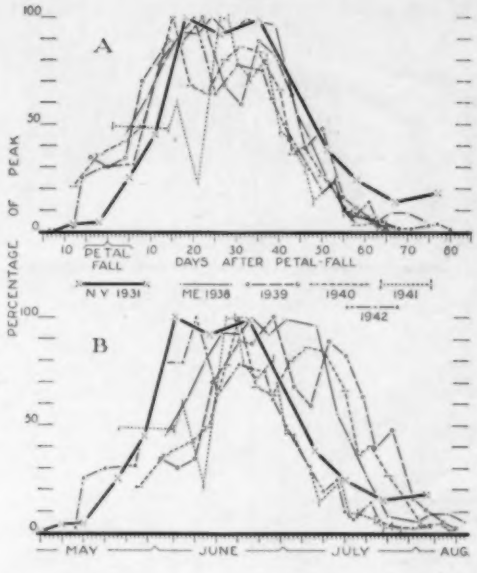

FIG. 4.—Plum curculio—adults of the first brood in the apple trees. On each date, the trees were jarred, the curculios were collected, counted, and returned to the trees from which they came. Each curve presents the records of a single year. The heavy curve presents data by Chapman in the Hudson Valley, 1931. The lighter curves show data for 5 years at Monmouth, Maine, 1938 to 1942. To make the two scales coincide, A should be shifted to the right until "Petal-fall" coincides with May 29–30 (the average date of petal-fall) on scale B.

Although the records of the individual

Table 2.—A comparison of data on the calendar scale, with the same data on the petal-fall scale. Rhagoletis pomonella, emergence of adults at Monmouth, Maine, during the 10-year period, 1933–1942.

Percentage of Total Emergence	Calendar Scale		Petal-Fall Scale	
	Mean number of days after average date of petal-fall		Mean number of days after petal-fall	
	Mean	S.D.	Mean	S.D.
0.10	29.06	5.62	27.81	2.76
10.00	38.12	4.25	37.95	3.09
25.00	42.77	4.30	42.72	2.75
50.00	48.23	4.49	48.53	2.54
75.00	54.39	4.16	54.27	2.60
90.00	59.52	3.80	59.35	2.83

years are not shown in figure 2 attention may be called to an interesting observation. On the calendar scale the earliest emergence followed the 1941 curve practically throughout the emergence period. On the petal-fall scale the earliest emergence follows the curves of 1938, 1934, and 1936, as they successively became the earliest during the advance of the emergence period. A similar change occurred in the curve of latest emergence. On the calendar scale, latest emergence followed the curves of 1935 and 1939, while on the petal-fall scale the latest emergence follows the 1942 record. The histograms (Fig. 1, 3 and 6) illustrate the tendency to approach the form of a normal distribution. Theoretically, the data on both scales may be expected to approach a normal distribution, but because the variation is reduced, the data on the petal-fall scale should approach a final form more promptly than on the calendar scale. The approach to the normal distribution, therefore, should be more marked on the petal-fall scale than on the calendar scale, when the records include a rather short series of years. The longest series of records—10 years—is shown in figure 1. Here the data approach a normal distribution on both scales, although the data plotted on the petal-fall scale appear slightly more symmetrical, and the mean is slightly higher than on the calendar scale. Figure 3 is rather unusual in that the data on the petal-fall scale appear less regular than on the calendar scale. The tendency here also, however, is to form a higher peak, and a slightly closer approach to the normal distribution on the petal-fall scale.

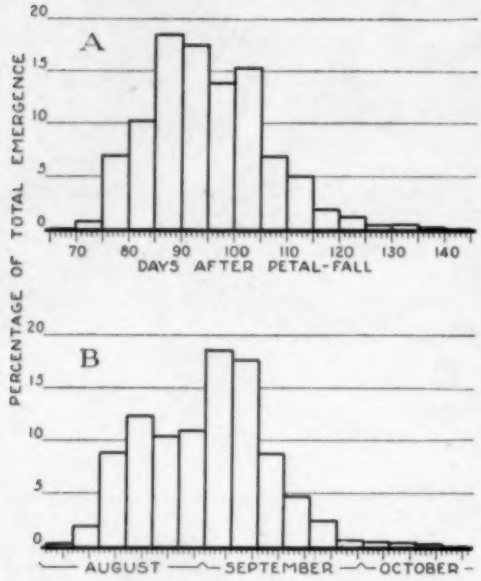

FIG. 5.—Plum curculio—emergence of adults from the soil. A 6-year average, 1936, and 1938 to 1942, based on a total of 34189 adults.

The increase in the height of the peak on the petal-fall scale is exaggerated in the data given in table 3, but probably it would be reduced somewhat if records of a longer series of years were available.

In view of the comparatively small total number of individuals included in the 5-year period, the data presented on the petal-fall scale, (Table 4), form a surprisingly smooth curve. The use of the petal-fall scale is helpful when the records are based upon comparatively small numbers of individuals.

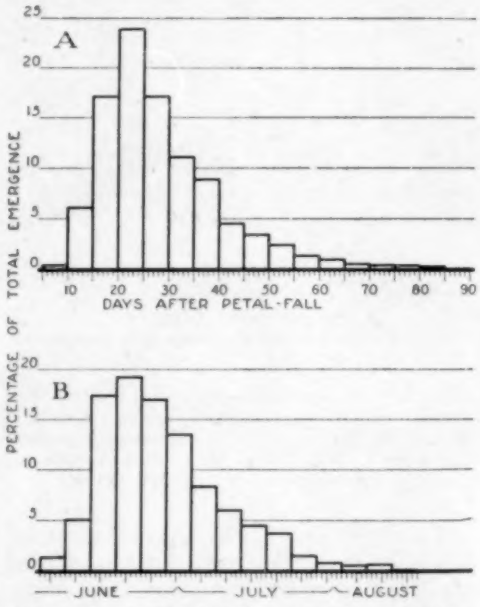

FIG. 6.—Apple seed chalcid—emergence of adults. A 7-year average, 1936 to 1942, based on a total of 13432 adults.

In a long series of years it is expected that probably the data on both the petal-fall and the calendar scales would not only approach the form of a normal distribution curve, but the means on the two scales would approximately coincide. Confirming the expectation that the means on

the two scales should coincide, the mean dates of emergence of specified percentages of fruit flies on the calendar scale were found to coincide almost exactly with corresponding means on the petal-fall scale (Fig. 2 and Table 2).

Since it appears that timing insect life histories on the petal-fall scale reduces the variation between years, when several years' observations from one locality are summarized, it may be expected that records from two distant localities would coincide more accurately on the petal-fall scale than on the calendar scale. In fact, one reason often advanced for tying insect life history data to phenological events, is to facilitate the comparison of data from distant localities. In seeking material from some other locality for comparison with Maine records, data on plum curculios in apple trees, recorded by Chapman (1938) in the Hudson Valley seemed to be suitable. In 1931, Chapman states that the curculios were returned to the apple trees after the counts were made. The same procedure was followed in Maine throughout the five years. The fact that the year 1931, in which Chapman's records were made, was not the same as any year for which Maine records are available, should offer no obstacle to the comparison of the data, for comparisons between years should be made as readily as comparisons between localities. Chapman published jarring records for four years, but the curculios were returned to the trees only in 1931, and his records for the other years, therefore, are not comparable to the Maine records.

Table 3.—Data on the petal-fall scale compared with the same data on the calendar scale. *Conotrachelus nenuphar* larvae leaving fallen apples. Average of 5-year period. 1938–1942, based on 11959 larvae. Data presented in 5-day periods, day indicated being last day of period in each case.

Petal-Fall Scale		Calendar Scale	
Days after Petal-fall	Per cent Emerged	Date	Per cent Emerged
35	0.5	July 3	2.2
40	3.3	8	4.4
45	7.5	13	10.7
50	14.9	18	12.7
55	33.9	23	16.1
60	13.9	28	22.0
65	10.3	Aug. 2	18.0
70	6.7	7	5.5
75	4.6	12	3.7
80	2.3	17	3.0
85	1.2	22	1.2
90	0.59	27	0.38
95	0.14	Sept. 1	0.12
100	0.09	6	0.04
105	0.0	11	0.06

Table 4.—Data on the petal-fall scale compared with the same data on the calendar scale. *Saperda candida*, emergence of adults. Percentages based on total emergence of 170 adults during the 5-year period, 1938–1942, presented in 5-day periods.

Petal-Fall Scale		Calendar Scale	
Days After Petal Fall	Per Cent Emerged	Date	Per Cent Emerged
10	—	June 8	6.5
15	7.1	13	11.8
20	16.5	18	7.7
25	28.2	23	7.7
30	14.7	28	28.8
35	5.9	July 3	12.9
40	8.8	8	5.9
45	3.5	13	1.2
50	2.4	18	3.5
55	2.4	23	2.9
60	1.2	28	1.2
65	1.2	Aug. 2	1.8
70	4.7	7	0.59
75	0.59	12	3.5
80	0.59	17	2.4
85	1.8	22	0.59
90	—	27	0.59
95	0.59	Sept. 1	0.59

The results of the comparisons of the New York and the Maine records are shown in figure 4. On the calendar scale, the New York record is earlier than most of the Maine records. On the petal-fall scale the New York record appears to coincide well with the Maine data within the limits of variation observed during the 5-year period.

CONCLUSIONS.—When insect life history data including records of several years, and charted on the calendar-date scale, were rearranged to the petal-fall or phenological scale, the relative positions of the annual records were modified, and the summaries of the records were changed.

When the records included a sufficiently large number of years, it appears that the data on each scale approached the form of a normal distribution curve. The means on both scales approximately coincided, but the deviation from the mean was distinctly less on the petal-fall scale.

The use of the phenological scale formed a smoother curve than the time scale when

the records included a comparatively small number of individuals.

Compared with the calendar scale, the petal-fall scale offers a somewhat better basis for considering data covering several years in one locality, and for comparisons of data from two or more separate localities.

The petal-fall scale makes possible the prediction, within closer time limits, the occurrence of events in the life cycles of insects.

It seems probable that the phenological scale may form a useful basis for the study of the effect of temperature and other climatic factors that influence the seasonal cycles of insects.—11-29-43.

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Size Specifications for Fine Powders[1]

ERNEST L. GOODEN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The subject of this paper is the drafting of particle-size specifications for those insecticidal powders (including diluents) that are essentially subscreen, that is, fine enough to pass through the finest testing sieves. The ordinary dusting and spraying preparations come in this class. Commercial dusting sulfurs, for example, are commonly described as 93, 95, or 98 per cent passing the No. 325 sieve. In the U. S. Standard Series, the sieve bearing this number is the finest except one, the No. 400. The openings of these two sieves are respectively 44 and 37 microns.

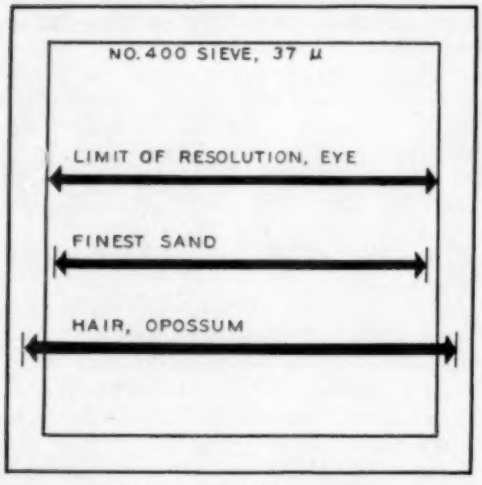

FIG. 1.—Relation of certain small magnitudes. Smaller square represents opening of finest sieve in the U. S. Standard Series; larger square, the finest sieve in common use. Limit of resolution of human eye calculated from data of Johannsen (1918). Diameter shown for finest sand (=coarsest silt) is average between value in U.S.D.A. classification and that of the International System. Hair diameter from Laidlay (1942).

[1] Eastern Branch Program, 1943.

The point of transition from the sieve range to the subscreen region is at a unique place in the scale of sizes. The U. S. Standard sieves Nos. 325 and 400 just mentioned both have their spacings near the limit of resolving power of the human eye. In other words, the boundary between screen and subscreen material is roughly the boundary between visible and microscopic particles. In soil science we have approximately the same boundary between sand and silt. With reference to man and some of the common fur-bearing animals, the limiting diameter is literally a hairsbreadth. A comparison of these magnitudes is shown in figure 1.

Any specification must be framed with some regard to means of testing. For obvious reasons the testing of subscreen powders with respect to particle size could hardly be so simple or easy as the testing of material composed of tangible grains, such as gravel and builders' sand. Not only are the operations more complicated but determination of the accuracy is less direct, so it is hard to prove the test. Even among sieves there are complications near the fine end of the series; the opening does not have the simple form that it has in the coarsest sieves, because the wires are nearly as large as the openings. The assignment of a nominal diameter of 44 microns to the No. 325 sieve, for example,

signifies that if the wires were straight instead of being crimped, with the same size and spacing frequency that they actually do have, the projection of the opening would be a 44-micron square. Fine-sieve testing is further complicated by the refusal of many fine powders to pass through the appropriate sieves unless the particles are coaxed by wetting and copious washing.

Particle-size specifications may be directed to either of two characteristics—size distribution, or a single value that is representative of the whole sample. In either case, facilities for testing must be taken into account. Distribution analyses are made by microscopic measurements, sedimentation, elutriation, or (with coarse powders) sieving. A distribution analysis, if complete, can be integrated into a suitable average value, but in subscreen work the analyses are inclined to stop too short on the fine end of the range for a reliable average to be computed. As to whether distribution or average is the more desirable determination, the distribution, if complete, gives more information but the average gives information that is more pertinent, more concise, and easier to obtain experimentally.

Determination of average or integrated values, expressed either as specific surface or as surface-mean diameter, is made by gas or liquid permeation or by gas adsorption. The most convenient means is air permeation. This method has been the subject of much recent study in several widely separated parts of the world. In this country it has been subjected to extensive tests on portland cement and related materials by the National Bureau of Standards (Blaine 1941), the United States Bureau of Reclamation, Cement Laboratory (1941), and the American Society for Testing Materials, Working Committee on Fineness (1942). Cooperating in the investigation sponsored by the A. S. T. M. were 15 industrial companies, 3 federal laboratories, 1 state laboratory, and 1 association of manufacturers. In the Bureau of Entomology and Plant Quarantine a self-calculating form of the air-permeation apparatus has been developed (Gooden & Smith 1940; Gooden 1941a, 1941c, 1942). This self-calculating apparatus has become the principal means of particle-size testing in the Bureau (Gooden 1941b, 1943; Carter & Gooden, 1943), and is known to have been constructed at about a dozen or more places outside the Bureau. It has been placed on the market by a manufacturer of scientific instruments.

If specifications are to be written on the basis of average diameter, the term average diameter must be defined, which is somewhat difficult. Even by that simplest and most unscientific method of averaging, wherein each particle is assigned a diameter by microscopic measurement

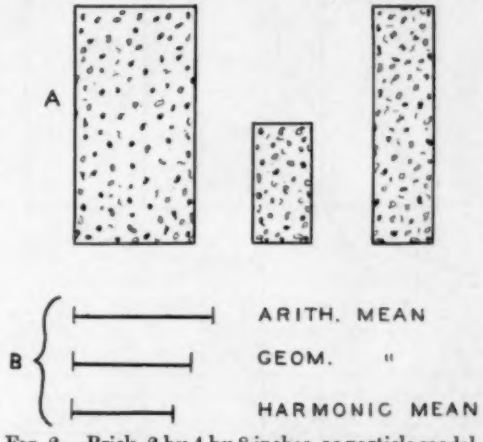

FIG. 2.—Brick, 2 by 4 by 8 inches, as particle model. (*A*) Face, end, and edge views. (*B*) Magnitudes of various mean dimensions.

and the arithmetic mean of these values is taken as the average diameter of the sample, two observers will not get the same result; one will disregard small particles considered by the other as significant, and nobody can tell exactly where to draw the line. The variation in results between different systems of averaging is greatest when the dispersity of sizes is great and when the particle shapes are very irregular, as in needles or flakes.

A good model to represent an irregular particle is a 2-by-4-by-8-inch building brick. One may choose to compute an average from determination of numerous diameters, including all the diagonals, or may use only the three principal dimensions—length, width, and thickness. The latter plan is simpler, but even there the problem is indefinite; the arithmetic mean is 4.7 inches, the geometric mean 4.0, and the harmonic mean 3.4 (Fig. 2).

In this simple case the harmonic-mean dimension amounts to the same thing as the surface-mean diameter. An illustration

of the way this property applies in powder technology is shown in figure 3, where we have more bricks. These are laid to form a pavement, in a manner constructionally unorthodox, but statistically very good. One-third of the bricks are resting on their faces, one-third on edge, and one-third on end, in the equivalent of a random distribution of tenable orientations, but they are all fitted together to cover the ground completely, with no overlapping. When

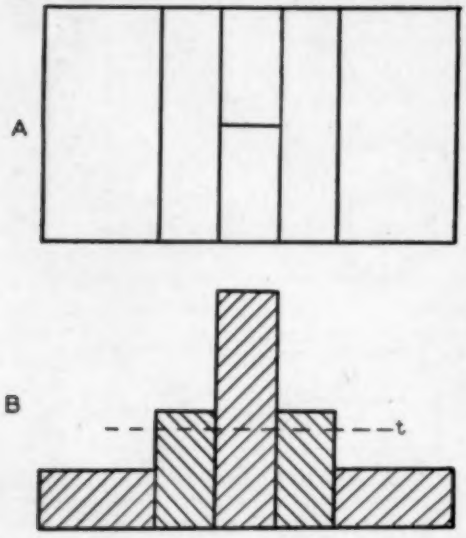

FIG. 3.—Irregular brick pavement as particle-study model (*A*) Plan of unit pattern, using 2-by-4-by-8-inch bricks. (*B*) Vertical section; height at broken line *t* is the average pavement thickness.

the average thickness of the pavement is computed it is found to be exactly equal to the harmonic-mean dimension or surface-mean diameter referred to above. If a number of sizes of brick are used in the same pavement, with random orientation within each size, the rule still holds that the surface-mean diameter of the whole lot is the same as the average thickness of the pavement. This illustrates the theoretical relation between surface-mean diameter and covering power in dusting powders. In an idealized case such as that of the bricks, the surface-mean diameter in microns is numerically equal to the number of cubic centimeters of solid material required to cover a square meter.

It will be noted that in the case of the brick the surface-mean diameter was nearer to the smallest dimension than to the largest. This is often true; and where there is a multifold variation in the three dimensions within a given particle, the surface mean is always of the same order as the smallest dimension, a fact of tremendous practical importance in judging the fineness of flaky materials, as talc, pyrophyllite, phenothiazine, and the like. In these materials the thinness of the particles contributes physical qualities belonging to fineness, without the particles appearing particularly fine under the microscope. The great influence of the smallest dimension on the average for a single particle has a counterpart in the influence of small grains on the average for the whole sample. A fine fraction has more influence than a coarse fraction present in equal percentage. In fact, the introduction of a moderate percentage of exceptionally coarse material has practically no effect on the average. These two parallel principles, with regard to small dimensions and fine fractions, make it very difficult to convert the results of a superficial or incomplete distribution analysis to surface-mean diameter by calculation. Fortunately this average is measured directly by the permeation methods.

An important question is, How exacting should particle-size specifications be? It has been claimed that in one construction job over $200,000 was wasted through inefficient and too restrictive requirements in regard to size distribution of sand and other aggregate (Abrams 1941). If this is true, it would be easy to make similar mistakes in working with insecticides. For certain investigational experiments it is sometimes necessary to use closely sized fractions, and these usually have to be prepared to order, at great expense. For general purposes, on the other hand, insecticidal powders cannot feasibly be supplied in any other form than with a particle-diameter range from zero up to many times the average of the product.

CONCLUSIONS.—The facts presented lead to the conclusion that suitable specifications for a given fine powder for insecticide use would normally consist of one or both of two specifications: (1) A specification as to surface-mean diameter and (2) specification of an approximate maximum limit of diameter. A minimum limit is infeasible. The maximum limit is necessary in case the presence of an appreciable quantity of material above a certain screen size would be objectionable

because, for example, of danger of clogging orifices of spray nozzles. No assurance against danger from this quarter is given by the specification on average diameter, whether the failure to pass the given sieve is due to simple coarseness or to irregular shape. The question of which is more important, the average or the maximum limit, depends on the use to which the powder is to be put; if *both* characteristics are important, *both* must be specified, for there is no dependable correlation between them. The percentage above 37 microns (the finest sieve) in an essentially subscreen product is not an index of the overall fineness (cf. Goodhue 1938), but comes nearer to being a composite function of average fineness and dispersity (Fig. 4).

Sieve-size specifications.—The sieve-size specification should be in terms of the United States Standard Sieve Series. This series is fully described in a Letter Circular issued by the National Bureau of Standards (1940). Reference is often made to 150- and 300-mesh sieves; these numbers do not occur in the U. S. Standard Series. The standard openings vary in geometric steps of such magnitude that it takes four steps to double the diameter; so that a suitable size for any purpose within screenable magnitudes can be found in the standard series.

The sieve-size specification for a fine powder must also say whether the test is to be wet or dry.

Mean-diameter specifications—The specifications of surface-mean diameter must include a reasonably definite specification of the method of testing. Granted that the method is to be air permeation, it is not necessary to specify the exact type of air-permeation apparatus to be used, but there should be restrictive provisions to make the conditions of test such as have been proved by experience to be suitable. The method is based on the principle that air under differential pressure will flow more readily through a bed of coarse powder than through an otherwise equal bed of fine powder. With this point settled, limits should be placed on the porosity of the bed, the absolute pressures allowable within the system, and the apparent linear velocity of air within the sample. Whether the apparatus is self-calculating or not is immaterial, but for clarity the specification should either state the formula accepted as expressing the permeability-fineness relationship, or else

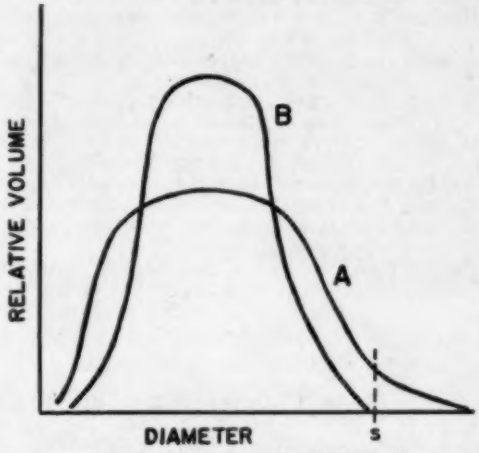

FIG. 4.—Distribution curves (uncalibrated) of two powders with similar average (surface-mean) diameters but different dispersities. Powder *A* has an appreciable fraction above the size of the finest sieve (indicated at *s*), while powder *B* is 100 per cent subscreen.

state the fineness limits not only in terms of surface-mean diameter (or the equivalent specific surface) but also in terms of permeability. With provisions such as these any laboratory would be able with a minimum of expense and trouble to set up a device adequate for the test, and not be dependent on a specific model.

Illustration of particle-size specifications.—An example of particle-size specifications framed according to the principles herein set forth, but omitting some of the details that would be necessary in a formal draft, is the following for moderately fine sodium fluosilicate: "At least 90 per cent by weight shall pass a U. S. Standard No. 325 (44-micron) sieve, by dry test. The surface-mean diameter by air-permeation test shall be not more than 9 microns." These specifications are satisfied by one of the commercial grades.—1-7-44.

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A Comparison of Dust and Spray Programs for Codling Moth Control[1,2]

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In the control of apple pests, any program based on the use of dusts has always had a strong appeal, not only on account of the greater speed of operation and the simplicity and relative cheapness of the equipment required but also because of economy in labor as compared to the standard operation of spraying. While earlier studies have demonstrated that dusting may provide an effective means of combating certain orchard pests, this method never came into general use largely because at that time it failed to give adequate commercial control of other important pests such as the codling moth.

In view of the advances that have been made in the development of dusting equipment, however, as well as recent improvements in the physical properties of the dusts themselves, and because of the wartime shortage in labor that now confronts our fruit growers, it has seemed advisable to reopen the question of dusting, particularly as this applies to such basic operations as scab and codling moth control.

This paper represents but one part of a larger cooperative endeavor that is designed to establish the place of dusting in our apple pest control program. The major project is being carried out in different sections of the state under the joint leadership of Mr. Martin Barnes and Dr. Kenneth Parker of Ithaca, the writer and Dr. J. W. Hamilton of Geneva and Mr. J. L. Brann and Dr. D. W. Hamilton of the Poughkeepsie Laboratory, Dr. D. W. Hamilton representing the Bureau of Entomology and Plant Quarantine. The studies reported in this paper were conducted in the Western New York fruit belt in the vicinity of Geneva.

A McIntosh orchard of approximately 250 mature trees heavily infested with both codling moth and apple scab was selected for the tests. Two-thirds of the orchard was used for experimental purposes, the remainder being cared for by the grower. Notwithstanding the efforts of the owner who applied an abbreviated spray program, the crop on his portion of the orchard was practically a total loss as a result of the failure to control both codling moth and scab, the trees being better than 50 per cent defoliated by scab in mid-summer, while of the fruit itself practically none escaped damage by

[1] Journal Paper No. 573, New York State Agricultural Experiment Station, Geneva, N. Y. January 5, 1944.
[2] Eastern Branch Paper, 1943.

Table 1.—Comparison of dust and spray programs for codling moth control, 1943. Based on dropped fruit.[1]

TREATMENT	NUMBER OF DROPPED FRUITS COUNTED	PER CENT DROPPED APPLES	DEEP WORM HOLES PER 100 APPLES	PER CENT FREE FROM CODLING MOTH INJURY
Spray: Sulfur-lead arsenate	1788	18.3	46.5	60.4
Dust:				
Sulfur-lead arsenate-nicotine 60-20-20	2241	21.1	40.7	66.0
Sulfur-lead arsenate-nicotine 75-15-10	1232	18.7	50.0	56.7
Sulfur-lead arsenate 80-20	1630	27.1	75.5	43.1
Checks—untreated	7247	77.9	105.6	15.1

[1] These McIntosh trees did not receive a "stop drop" spray which influenced the amount of dropped fruit just prior to harvest.

either the codling moth or scab and nothing was harvested from this block.

Experiments included tests on 28 trees with lead arsenate sprays and on a total of 70 trees with various dust combinations. All sprays were applied with a *Friend* motorized sprayer equipped with a 20 gallon a minute pump carrying 400 pounds pressure at the pump. Approximately 15 gallons of spray per tree was used in each of the summer applications. Dusting was done in the quiet of the late evening to take advantage of the more favorable air conditions and the presence of dew which helped in residue building. A standard *Bean* self-mixing orchard duster mounted on a 1.5 ton truck was used for applying the dust. Treatments were made to both sides of each row using from 2 to 2.5 pounds of dust per tree at each application. The summer spray program consisted of six applications at approximately 10-day intervals between June 21 and August 23. Dust treatments were made at the same time the corresponding sprays were applied except that one additional dusting was made one week following the final spray, August 30, making a total of seven dust treatments. The materials were as follows:

Sprays—for each 100 gallons

1. Micronized wettable sulfur, 4 pounds in the first cover spray and 2 pounds in all later applications.
2. *Corona* lead arsenate, 3 pounds.
3. Fresh hydrated lime, 3 pounds.
4. Soybean flour (*Spraysoy A*), 8 ounces.

Dusts

Formula 1. 60–20–20 dust containing 60 pounds *Microsul* dusting sulfur (80 per cent sulfur and 20 per cent inert;[1]) 20 pounds *Corona* lead arsenate; 20 pounds *Black Leaf 155.*

Formula 2. 75–15–10 dust containing 75 pounds *Microsul* dusting sulfur; 15 pounds *Corona* lead arsenate; 10 pounds *Black Leaf 155.*

Formula 3. 80–20 dust containing 80 pounds *Microsul* dusting sulfur and 20 pounds *Corona* lead arsenate.

It is characteristic of the variety McIntosh to drop the codling moth infested fruit during the summer months. For this reason the dropped fruit was collected several times during the season and the deep worm injuries recorded. The data on the dropped fruit is given in table 1. There was no harvest spray applied which undoubtedly influenced the amount of dropped fruit on the sprayed and dusted trees. Up to September 1 practically all the dropped fruit was wormy. According to the counts, approximately 20 per cent of the crop on the treated trees dropped prior to harvest. On the untreated trees or checks where there was a greater proportion of wormy fruit the drop was correspondingly greater, namely, 78 per cent.

Table 2 gives the data on the harvested fruit. These figures indicate the amount of marketable fruit harvested and also the number of stings occurring on the picked fruit. The deep worm counts represent for the most part the late second brood injury and, taken alone, are not a true picture of the worm control.

[1] Manufactured by Barker Chemical Company at Barker, N. Y.

Table 2.—Comparison of dust and spray programs for codling moth control, 1943. Based on picked fruit.

Treatment	Fruits Counted	Per Cent Crop Harvested	Stings on 100 Apples	Deep Worm Holes Per 100 Apples	Per Cent Clean Fruit
Spray: Sulfur-lead arsenate	6617	81.7	22.7	0.6	83.2
Dust:					
Sulfur-lead arsenate-nicotine 60-20-20	8381	78.9	10.3	1.0	93.1
Sulfur-lead arsenate-nicotine 75-15-10	5368	81.3	10.9	1.1	89.6
Sulfur-lead arsenate 80-20	4395	72.9	27.6	5.8	75.9
Checks—untreated	2055	22.1	11.7	35.2	62.8

In table 3 are given the figures for the total crop including both dropped and picked fruit, and these counts represent more nearly the true efficiency of the various treatments as measured by codling moth control. Although these experiments represent but a single season's work, the results as presented seem to warrant the following conclusions:

The sulfur-lead arsenate dust (80–20) did not give as good protection from codling moth as did the standard sulfur-lead arsenate spray program.

The addition of nicotine in the form of *Black Leaf 155* to the sulfur-lead arsenate dust resulted in approximately the same control of deep codling moth injuries as where the liquid spray was used. There appeared to be a significant difference in the number of stings in favor of the nicotine dust.

The control on the plat representing the 15 per cent lead arsenate and 1.4 per cent nicotine dust formula was comparable to that on plat 2 which received the 20 per cent lead arsenate and 2.8 per cent nicotine combination.

The early season scab program was the same on all plats including a delayed dormant spray of 1 to 50 lime-sulfur, two pink sprays with micronized wettable sulfur 5 pounds in 100 gallons, a calyx spray with 1 to 50 lime-sulfur followed by a spray with micronized sulfur and lead arsenate 10 days later. Materials used in the summer have already been mentioned.

Table 4 gives the lead and arsenic residues on the fruit at harvest. The liquid spray of sulfur and lead arsenate left double the residue as compared with dust, plats 2 and 3, both of which contained bentonite-nicotine (*Black Leaf 155*). On the other hand, the residue on dusted plats 2 and 3 was twice that left by the sulfur-lead arsenate dust. Apparently the bentonite in the *Black Leaf 155* influenced the adhesive properties of the dusts. It is also interesting to note that both codling moth and apple scab control on the dusted

Table 3.—Comparison of dust and spray programs for codling moth control, 1943. Based on total crop including both dropped and picked fruit.

Treatment	Fruits Counted	Stings on 100 Apples[1]	Deep Worm Holes Per 100 Apples	Per Cent Clean Fruit
Spray: Sulfur-lead arsenate	8405	22.7	9.0	79.1
Dust:				
Sulfur-lead arsenate-nicotine 60-20-20	10622	10.3	9.4	87.4
Sulfur-lead arsenate-nicotine 75-15-10	6600	10.9	10.2	88.5
Sulfur-lead arsenate 80-20	6025	27.6	24.7	67.1
Checks—untreated	9302	11.7	90.1	25.6

[1] Owing to the small number of stings on fruit dropped prior to harvest, no attempt was made to record stings on the drops.

plats corresponded with the residue deposits, that is, the heavier the residue the more efficient the treatment.

Spraying in most Western New York apple orchards is a more expensive and time-consuming operation than in many other apple producing sections of the State because the larger codling moth population requires greater effort on the part of the grower if he is to produce a marketable crop. The average grower prefers to apply the spray while riding the tank. The more successful growers, however, use two men, one spraying from the rig and the other from the ground, walking around and beneath the trees covering those portions including the interior of the tree not reached by the man on the tank. This latter method of spraying explains why dusting is approximately four times faster than spraying.

On the other hand, basing our calculations on amounts ordinarily applied, dusts are considerably more expensive than sprays, and especially so when an ingredient such as nicotine is employed. The 75–15–10 dust appeared to be the most practical combination from the standpoint of both cost and control. It sold for 11 cents a pound retail. Using 2 pounds of dust on a tree that requires 10 gallons of spray at 0.75 cent per gallon per application, the cost of the dust would be approximately 3 times that of the spray for materials alone.

The following is an attempt to compare the cost of dusting and spraying. This is obviously not a true picture of the relative cost of the two operations since no two growers will have exactly the same setup, but the figures given should serve as a useful guide for working out the item of cost in specific cases.

	Spray		*Dust*
2 men			
10 hrs. @ $0.50	$10.00	2½ hrs.	$2.50
Machinery			
10 hrs. @ $1.00	10.00	2½ hrs.	2.50
Materials			
4000 gals. @ $0.0075	30.00	800 lbs. dust @ $0.11	88.00
	$50.00		$93.00

With regard to the higher cost of dusting, one should bear in mind that but one season's work is represented in these tests. There are indications in the data that suggest ways of reducing the cost of dusting. It may be possible to reduce the number of applications of the more expensive dusts by their use only during critical periods. The substitution of adhesives or stickers in place of certain of the more expensive ingredients may also be possible. These suggestions are to be incorporated in the tests for another season.

When considering the smaller initial investment in machinery required for dusting and the saving in labor which could be diverted to other profitable operations as well as several other points such as the expense of providing an adequate water supply for spraying and the value of emergency dusting or of dusting when it would be impossible to pull a sprayer in a muddy orchard, the actual difference in the cost of the two methods may not be as great as it at first appears. On the other hand, one should not lose sight of the fact that to be effective in the control of a pest such as the codling moth, dusting is likely to demand radical changes in the established farm routine, changes that it may not always be easy to effect, particularly when labor other than that of the owner is involved.

While the results presented in this preliminary report represent but a single season's work in a moderately infested orchard and on this basis certainly do not warrant any far-reaching conclusions, they do suggest that under conditions comparable to those encountered in this planting the adoption of a dusting program for codling moth control at least under present conditions, may prove both effective and profitable, particularly in view of the existing acute shortage in labor.—1-14-44.

ERRATUM

Mr. A. H. Madden has called attention to the following error in the article entitled "The Effectiveness of DDT as a Residual Spray Against Houseflies" in the February, 1944, number of the JOURNAL: Page 133, Table 2, headings for columns 2 and 3 now read "0.335 milligram per square foot" and "0.325 milligram per square foot" but should read "0.335 gram per square foot" and "0.325 gram per square foot." (*i.e.*, milligram should read gram in both cases). Also, on page 127, Column 1, under heading "JAR TESTS," fifth line—0.8 gram should read 0.08 gram.

The Insect Menace to Shade Trees in the Northeast[1]

E. P. Felt and S. W. Bromley, *Bartlett Tree Research Laboratories, Stamford, Conn.*

No two seasons are just alike. There are not only annual changes but cyclic variations. Just at present we are in a cycle which is marked by increasing injury to shade or shelter trees. This is resulting in irreparable damage in many cases and promises to become serious unless there is a more general understanding of the situation. The pressure of war demands and the difficulties incident to securing men, materials and equipment have tended to develop a false sense of security or to justify a lull in activities entirely unwarranted by actual developments. It is only necessary to look over the trees in some of the more important cities and to listen to explanations for the prevailing unfortunate conditions to get an idea of the shade tree situation. Trees require a generation to half a century or more to mature, consequently current damage is far reaching in effects. It seems to the writers that a duty rests upon most entomologists to evaluate these developments and aid in conserving national assets. It is feared that some restrict themselves too much to special fields.

The elm is a deservedly favorite shade tree in the northeast. Unfortunately it is subject to attack by a number of destructive insects and serious plant diseases. These, it should be pointed out, are not disconnected factors. They are inter-related and the inter-relation is becoming more evident with the passage of time. The elm leaf beetle, *Galerucella xanthomelaena* Schrank, is too well known to require extensive notice. Its depredations vary here and there but in many localities its operations have progressively weakened valuable trees over a series of years and what the elm leaf beetle has missed cankerworms, *Paleacrita vernata* Peck and *Alsophila pometaria* Harris, have found, at least in some localities. The essential to be noted is that though attacks by insects are controllable, relatively little is being done. The trees are being progressively weakened and many of these are in a condition extremely favorable to attack by the European elm bark beetle, *Scolytus multistriatus* Marsh. This insect limits its operations largely to weakened parts of trees although in some places in southwestern Connecticut, it has increased to such an extent as to severely injure, if not kill large parts of good sized trees.

An even more serious problem is due to the fact that the European elm bark beetle is the principal carrier of the deadly Dutch elm disease, *Ceratostomella ulmi* Buis. Both thrive in sickly wood and one supplements the activities of the other to a great extent. The extensive Federal and State operations of earlier years for eradication, really the control, of the Dutch elm disease have been suspended in large measure and the responsibility for the protection of elms now falls upon local political units, towns, villages and cities mostly. Unfortunately the officials in areas where the Dutch elm disease was extremely injurious in earlier years have come to regard the situation with tolerance, assuming that the relative freedom from injury under the rigid control operations justified by the eradication policy would apply also when these latter are suspended. Such is far from the case and the probabilities are that unless there is a fuller realization of the situation and its possibilities there will be enormous losses of practically irreplaceable village and street trees in the next decade or thereabouts. Our present knowledge does not warrant a statement to the effect that this killing will be sweeping. The indications are that it will be locally serious although the ultimate result may be nearly as disastrous as though a large proportion of the elms in infected localities were killed within a year or two. Tree sanitation, including under this term, protection from leaf-eating insects and the prompt removal and burning of sickly and dead wood are the most hopeful control measures since much of the spread of the disease by the European elm bark borer is to a great extent local. Such spread is restricted to approximately five hundred feet although it must not be forgotten that under some conditions the disease may be carried to much greater distances.

The oaks, although relatively few are grown as highway trees, are important

[1] Eastern Branch Program, 1943.

shade trees in parks and on private grounds. Repeated defoliation by canker-worms, *Paleacrita vernata* Peck and *Alsophila pometaria* Harris, forest tent caterpillars, *Malacosoma disstria* Hubn. and gypsy moth caterpillars, *Porthetria dispar* L., weaken the trees and make them attractive to the destructive two-lined chestnut borer, *Agrilus bilineatus* Web. Cankerworms are frequently serious pests in southwestern New England and the stripping by them or the weakening effects of drought is often followed by extensive dying of oaks killed by the two-lined chestnut borer. The same thing follows with such defoliaters as the forest tent caterpillar or caterpillars of the destructive gypsy moth. This last was exceedingly abundant and injurious on Cape Cod the past season because of the modified winter temperatures due to the proximity to the ocean whereas farther north or west there was general killing of the eggs above the snow line and consequently relative freedom from severe injury by this pest.

Incidentally, the winter of 1942–1943 was exceptionally severe, temperatures of 20° Fahrenheit below zero or lower being recorded from a number of New England localities. The result was the blasting of buds of many fruit trees and ornamental shrubs and vines. There was also severe weakening of the wood and killing of bark on the more tender trees and shrubs, the delayed effects of which will not be fully apparent for several years. European pine shoot moth, *Rhyacionia buoliana* Schiff, larvae suffered heavy mortality as in the winter of 1933–1934. The weakening of many trees has produced conditions favorable to invasion by a number of borers and troubles of this nature may be expected in the next few years.

The serious droughts which occasionally extend over several years are also important in producing conditions favorable to invasion by the two-lined chestnut borer in oak, attack by the bronze birch-borer, *Agrilus anxius* Gory, in the ornamental European birch and the spotted hemlock borer, *Melanophila fulvoguttata* Harris, in hemlock. There are also other complicating factors but too frequently drought is important and in the case of the more valuable trees of parks and on private grounds, it is entirely possible to prevent the serious consequences so frequently following a marked decrease in soil moisture and humus valuable for trees.

It should be noted that the greatly increased and the more extensive construction of recent years has materially affected many trees and resulted in killing by borers as well as death from actual drought or suffocation due to injudicious drainage, flooding or filling. Unfortunately these operations affect the more desirable trees because of their nearness to new installations of one kind or another. There is great difficulty in securing a general appreciation of what such changes mean until most of the damage has been done.

Somewhat unusual conditions occur in the pitch pine on Cape Cod. There it has somewhat the status of a desirable shade tree. Unfortunately the construction of buildings among pitch pines and especially the turpentine on newly painted structures results in attracting many turpentine beetles, namely, the black turpentine beetle, *Dendroctonus terebrans* Oliv. and the red turpentine beetle, *D. valens* Lec. The beetles attracted by the paint enter mostly nearby trees, causing a loss of those which are most desirable from the standpoint of the owner of the property. Painting in cool weather, especially in the fall, would lessen the probability of attracting the beetles and the consequent injury. Spraying the basal four feet of the trunk with a lime sulfur wash has given promising results as a deterrent or repellent.—11-29-43.

Lieutenant Erskine Livingstone writes (February, 1944) from Sicily. He may be addressed through APO #758, c/o Postmaster, New York. Lt. Livingstone also entered the army as a private but did not retain that status long. He is attached to the Sanitary Corps.

Lieutenant C. L. Ritchie is with the Sanitary Corps of the Army and is stationed at the San Francisco Port of Embarkation. He is concerned primarily with work dealing with the Typhus control program. Lt. Ritchie may be addressed at the Post Surgeon's Office, Ft. Mason.

The Effect of Some Insecticides in Aerosol Form against the Cyclamen Mite on Snapdragon[1]

L. D. Goodhue and Floyd F. Smith, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In previous publications Goodhue and coworkers (Goodhue 1942, Billings *et al.* 1942, Goodhue & Sullivan 1942, Sullivan 1942, Sullivan *et al.* 1942) have shown that insecticides can be dispersed in aerosol form by using as sprays solutions of them in a suitable liquefied gas. This method was shown by Smith & Goodhue (1943) to be applicable to the treatment of greenhouses with nicotine for the control of aphids. Extension of this method to include other greenhouse pests appears to be possible where fumigation is a practical means of control. This report includes the results of a number of preliminary acaricidal tests against the cyclamen mite, *Tarsonemus pallidus* Banks, and the most promising of these tests has been studied in a series of practical applications in the greenhouse.

Materials and Methods.—The 32 different insecticides tested were taken from commercial stocks of a purity considered adequate for such tests. Many of the compounds were chemically pure materials. Some were commercial samples of known purity. The liquefied gases were dichlorodifluoromethane (*Freon-12*) and methyl chloride purified for refrigeration purposes. Either of these gases is a good dispersing agent but methyl chloride is the much better solvent for most organic insecticides.

Solutions were prepared in small metal containers equipped with gas-tight valves and connections to which nozzles could be attached. A container carefully washed with acetone and chloroform was evacuated and the insecticide, if a liquid, was drawn in. The liquefied gas was then weighed in through a flexible hose. Solid insecticides were introduced either in solution or in solid form through an opening in the side of the container. Complete details for the preparation of solutions in liquefied gases will be found in a previous publication (Goodhue & Sullivan 1942). The amount of liquefied gas varied slightly, but this was not critical because the gas at the concentrations used had no insecticidal effect and the entire contents of a container were liberated for each test.

The test material was prepared by inoculating young snapdragon plants in 4-inch pots with cyclamen mites and allowing the mites to become well established in the growing tips. This usually took about 3 to 4 weeks. A continuous supply of mites was kept available. Plants with tips showing slight to moderate distortion were used in the experiments. Except as noted, the severely malformed tips were removed because the mites contained therein were too well protected to be reached by any spray, as had been determined in earlier experiments by the junior author.

For the preliminary tests the materials were sprayed into a Peet-Grady chamber containing the infested plants. After an exposure of 6 hours the plants were returned to the greenhouse, where they were kept for observation on the results of the treatment. The next day the degree of plant injury was noted and the dead and and living mites of all stages in several of the infested tips were counted. Another examination was made a week later. The results of these experiments are given in table 1.

Only a few of the insecticides tested on the cyclamen mite gave a high percentage of mortality. Butyl carbitol thiocyanate, diphenyl sulfide, and diphenyl sulfoxide were very effective, but they caused severe plant injury. Chloratone, which is a trichloro-tert-butyl alcohol, was effective only after standing for several days with methyl chloride. Some chemical reaction occurred during this period because solutions made up and sprayed immediately were not toxic. Acrylonitrile and lorol thiocyanate caused no noticeable plant injury, and were further tested in a 1152-cubic-foot section of a greenhouse at concentrations found effective against the cyclamen mites in the 216-cubic-foot Peet-Grady chamber. In these tests eight snapdragon plants were exposed overnight and counts of mites were made 2 days and 7 days later. The results are given in table 2.

[1] Eastern Branch Program, 1943.

Table 1.—Effect of various compounds used as aerosols against the cyclamen mite on snapdragon.

TEST NO.	INSECTICIDE MATERIAL	AMOUNT USED	LIQUEFIED GAS[1]	MITES EXAMINED Number	Mortality	PLANT INJURY
		Grams				
1	Pyrethrins I and II	0.4	*Freon-12*	98	0.0%	None
	Sesame oil	.9				
2	Rotenone	1.5	methyl chloride	138	0	None
	Propylene glycol oleate	1.0				
3	Derris resin	6.0	methyl chloride	102	0	None
	Turkey red oil	6.0				
4	Lorol[2] thiocyanate 95 per cent	5.5	*Freon-12*	213	100.0	None
28	Lorol[2] thiocyanate 95 per cent	2.5	*Freon-12*	74	87.8	None
5	Nicotine	6.0	*Freon-12*	33	21.2	Severe
	Oleic acid	3.0				
6	Acrylonitrile	20.0	*Freon-12*	510	100.0	Severe
	Oleic acid	3.0				
32	Acrylonitrile	10.0	*Freon-12*	69	92.7	None
	Oleic acid	3.0				
7	Butyl carbitol thiocyanate 80 per cent	6.0	*Freon-12*	48	81.3	Severe
33	"	2.5	*Freon-12*	116	7.7	Tips killed
8	Phthalonitrile	5.0	methyl chloride	29	3.4	None
	Oleic acid	2.5				
9	3-chloroacenaphthene	5.0	methyl chloride	30	20.0	Severe
10	Lorol thiocyanate 50 per cent	5.0	*Freon-12*	125	77.6	None
11	Oleic acid	5.0	*Freon-12*	181	1.7	None
12	Phenazine	3.0	methyl chloride	35	0	None
13	Diphenyl sulfide	5.0	*Freon-12*	75	94.7	Severe
34	Diphenyl sulfide	2.5	*Freon-12*	72	4.4	Moderate
14	Diphenyl sulfoxide	5.0	methyl chloride	27	100.0	Severe
27	Diphenyl sulfoxide	2.5	methyl chloride	22	0.0	Severe
	Oleic acid	2.5				
15	Phthalic glycerol alkyd resin	8.0	*Freon-12*	32	0	None
16	Diphenyl disulfide	5.0	methyl chloride	59	0	None
17	3-Chlorodibenzofuran	4.0	methyl chloride	21	38.1	None
18	Styrene dibromide	5.0	methyl chloride	24	0	None
20	Tetrahydronaphthalene	10.0	*Freon-12*	18	0	Severe
	Oleic acid	1.0				
21	o-Nitroanisol	2.0	methyl chloride	21	9.5	Severe
	Oleic acid	1.0				
22	3-nitro-2-iodo toluene	2.5	methyl chloride	48	18.4	Severe
23	Tetrachlorophenoxyethoxy ethyl chloride	5.0	methyl chloride	37	2.7	None
36	"	10.0	methyl chloride	112	2.7	None
24	Dicychohexylamine salt of 2,3,5-dinitro-o-cyclohexyl phenol	sat.		43	0	None
25	Diphenylene oxide	5.0	methyl chloride	85	0	None
26	Diphenylene oxide	5.0	methyl chloride	67	5.9	None
	Oleic acid	2.5				
29	Dibenzyl thiophene	5.0	methyl chloride	88	0	Moderate
	Oleic acid	2.5				
30	Diphenylamine	2.5	methyl chloride	49	18.3	Severe
31	Derris extract[3] in mannitan	10.0	methyl chloride	66	0	None
35	Prickly ash extract	2.0	methyl chloride	180	1.1	None
37	Chloratone (old solution)	5.0	methyl chloride	118	91.5	None
41	Chloratone (fresh solution)	5.0	methyl chloride	119	1.7	None
39	Bornyl and fenchyl thiocyanoacetates	5.0	*Freon-12*	161	14.3	Slight
40	Dibromoacrylonitrile	5.0	*Freon-12*	43	100.0	Severe
42	Lorol[2] thiocyanate 95 per cent	5.0	*Freon-12*	167	100.0	None
	Acrylonitrile	10.0				
44	Lorol[2] thiocyanate 95 per cent	2.5	*Freon-12*	441	99.1	None
	Acrylonitrile	5.0				

[1] The total weight of the solution in methyl chloride was 85 gm. ± 5 and that of the *Freon* solution was 125 gm. ± 5.
[2] "Lorol" is a term used to denote a mixture containing principally the lauryl radical. This mixture of thiocyanates contained 95 per cent of active materials.
[3] Contains 1.0 per cent of rotenone and 1.9 per cent of other derris extractives.

In two of the tests (38 and 43A), with *Freon* as the carrying agent, the kill was 82.8 and 83.9 per cent, respectively, on plants with dry foliage. In test 43B, in which foliage of the plants was wetted just before the fumigation was started, the kill was only 65.5 per cent. Half the dosage of thiocyanate killed 94.8 per cent of the mites in test 45, when the temperature was near 76° F., whereas in test 48, in which the temperature dropped to 58°, the kill was only 12.2 per cent. In test 49 with 25 gm. of lorol thiocyanate, in which methyl chloride was used as the propellant, a 98.4 per cent kill of mites was obtained whereas in test 50, with half that dosage, the kill was only 37.3 per cent, but again the temperature fell to 66°. In both instances the kill was somewhat higher with the methyl chloride as a carrier than in comparable tests with *Freon*. It appears that a temperature above 70° is necessary for a high kill with lorol thiocyanate as an aerosol. In test 46, where 12.5 gm. of lorol thiocyanate was mixed with acrylonitrile, only 22.9 per cent of the mites were killed, whereas in test 47 acrylonitrile alone killed none of the mites. In both these tests the temperature dropped below 60° during the night. In the tests where high kills were obtained with lorol thiocyanate the surviving mites were generally well protected in malformed tips. Single applications of sprays are incompletely effective against mites in such growths but several regularly repeated sprays are generally highly effective on snapdragons. It was, therefore, planned to use the aerosol from 2 to 4 times at weekly intervals to compare the results with those obtained by spraying.

In this practical test to control the cyclamen mite with lorol thiocyanate applied as an aerosol, two concentrations were applied, each 1, 2, 3, and 4 times at weekly intervals on snapdragons in two greenhouse units, each having a capacity of 1152 cubic feet. In each unit 100 potted snapdragons about 6 inches tall and uniformly infested with mites were separated into 5 groups of 20 plants each. Weekly treatments were made on April 23–24, April 30–May 1, May 7–8, and May 14–15. Those groups which had already received the required number of treatments were removed from the units and returned the next day. The results are shown in table 3. Two weeks after the last fumigation, records were made on the malformed and normal tips, the percentage of tips infested, the "lorol thiocyanate injury," and the general growth of all the plants.

It is seen that untreated checks in both

Table 2.—Effect of lorol thiocyanate and acrylonitrile used as aerosols against the cyclamen mite on snapdragon.[1] Beltsville, Md., 1942.

Test No.	Insecticide		Liquefied Gas		Temperature	Mites Examined (All Stages)		
	Material[4]	Amount Used	Material	Amount Used		Total	Surviving	Mortality
		Grams		*Grams*	°F.	*Number*	*Number*	*Per Cent*
38	Lorol thiocyanate[2]	25	*Freon*	263	72–80	180	31	82.8
43A	Lorol thiocyanate	25	*Freon*	273	74–66	81	13	83.9
43B	Lorol thiocyanate[3]	25	*Freon*	273	74–66	177	61	65.5
49	Lorol thiocyanate	25	methyl chloride	150	76–68	126	2	98.4
45	Lorol thiocyanate	12.5	*Freon*	130	76–76	97	5	94.8
48	Lorol thiocyanate	12.5	*Freon*	130	72–58	33	29	12.2
50	Lorol thiocyanate	12.5	methyl chloride	85	74–66	204	128	37.3
46	Lorol thiocyanate +acrylonitrile	12.5 25	*Freon*	270	78–56	109	84	22.9
47	Acrylonitrile	25	*Freon*	175	76–58	51	51	0
39, 43, 45, 50	Untreated checks	—	—	—	—	425	422	.7

[1] Greenhouse unit of 1,152 cubic feet capacity.
[2] The Lorol thiocyanate was 95 per cent pure.
[3] Plants with wet foliage at beginning of test.
[4] No plant injury was noted in any of these tests.

the 25 gm. tests with lorol thiocyanate and those with half that dosage were thoroughly infested with mites and stunted by their activities (Fig. 1, *C*). The plants in each group fumigated once (51 and 55) had a few mite-injured tips which contained living mites, whereas all groups of plants fumigated two, three or four times were free of mites. The growth of plants fumigated with the 25-gm. dosage of lorol thiocyanate was normal when fumigated once (51). Injury was slight on 3 of the 20 plants in group 52, which was fumigated twice, but the growth was not stunted. On the plants fumigated three or four times (53 and 54) the lorol thiocyanate injury was slight to severe and the plants were stunted, had elongated internodes and narrowed leaves, and were not producing flower spikes (Fig. 1, *B*). In the series with the 12.5-gm. dosage no injury or stunting was evident on groups fumigated one, two, or three times, but typical lorol thiocyanate injury and stunting of growth was evident on group 58, which was fumigated four times. From these results it is evident that two fumigations at weekly intervals with lorol thiocyanate in aerosol form can be expected to destroy an infestation of cyclamen mites on snapdragons without affecting the subsequent growth of the host (Fig. 1, *A*).

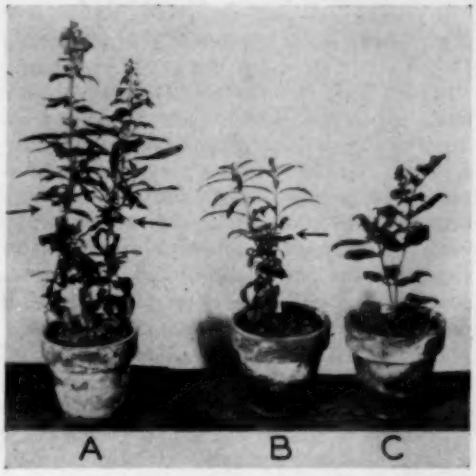

FIG. 1.—Effect of aerosol treatment with lorol thiocyanate against cyclamen mites on snapdragon. Mite-injured tips occurred at zones indicated by arrows. *A*, Typical plant from groups fumigated twice at either dosage; *B*, plant showing injury typical of those fumigated 3 times at the higher dosage or 4 times at the lower; *C*, untreated, mite-injured check.

Table 3.—Control of the cyclamen mite on snapdragon by fumigation with aerosols of lorol thiocyanate. Beltsville, Md., April-May, 1942.

Test No.	Materials in Aerosol	Times Fumigated[1]	Shoots at End of 6 Wks.			Plants	
			Malformed	Infested	Normal	Lorol Injury	Condition
		Number	*Number*	*Per Cent*	*Number*		
—	Untreated check	—	262	100.0	23	None	Malformed, stunted
51	Lorol thiocyanate 25 gm. Methyl chloride 170 gm.	1	5	20.0	318	None	Vigorous
52	Lorol thiocyanate 25 gm. Methyl chloride 170 gm.	2	0	0	359	Slight on 3 plants	Normal
53	Lorol thiocyanate 25 gm. Methyl chloride 170 gm.	3	0	0	243	Moderate on all plants	Stunted
54	Lorol thiocyanate 25 gm. Methyl chloride 170 gm.	4	7	0	379	Severe on all plants	Severe stunting,
—	Untreated check	—	274	100.0	0	None	Malformed, severe stunting
55	Lorol thiocyanate 12.5 gm. Methyl chloride 85 gm.	1	15	100.0	277	None	Normal
56	Lorol thiocyanate 12.5 gm., Methyl chloride 85 gm.	2	0	0	341	None	Normal
57	Lorol thiocyanate 12.5 gm., Methyl chloride 85 gm.	3	0	0	371	None	Normal, but delayed over No. 56
58	Lorol thiocyanate 12.5 gm., Methyl chloride 85 gm.	4	0	0	319	Moderate on all plants	Stunted

[1] Temperature range (°F.) for each fumigation: First, 82 to 68; second, 92 to 68; third, 78 to 56; fourth, 82 to 71.

In 1943 another series of plants was treated with the same dosages of lorol thiocyanate to check the results obtained in 1942. Only two fumigations were given, at an interval of 1 week, plants being used on which some tips were extensively malformed. No plant injury developed and a complete clean-up of the infestation was obtained at both dosages, except in 10 badly distorted tips on plants exposed to the 12.5-gm. dosages (Table 4). These results emphasize the need for removing badly injured tips before treating the plants with aerosols—a practice also found necessary for complete control when this thiocyanate is used in sprays.

Table 4.—Control of cyclamen mites on snapdragons by two fumigations with aerosols containing lorol thiocyanate. Beltsville, Md., March–April 1943.

Materials in Aerosol	Shoots at End of 4 Weeks—		
	Malformed	Infested	Normal
	Number	*Per Cent*	*Number*
Lorol thiocyanate 25 gm., in methyl chloride 170 gm.	166	0	78
Lorol thiocyanate 12.5 gm. in methyl chloride 85 gm.	136	7.3	34
Unfumigated	116	94.8	34

The results of these experiments indicate that lorol thiocyanate in aerosol form can be used to control the cyclamen mite on snapdragons where fumigation is practical. The high efficiency of this material in aerosol form obtained against the cyclamen mite in these studies compares favorably with the unpublished results obtained by the junior writer in tests with many insecticides in dusts and sprays over a period of several years. Its possible value against other pests is indicated by the fact that this material killed all *Myzus persicae* (Sulz.), *Aphis gossypii* Glov., and *Thrips tabaci* Lind. present on plants in all tests in the Peet-Grady chamber.

Summary.—Thirty-two different insecticides were tested in aerosol form in a preliminary way against the cyclamen mite on snapdragons in a 216-cubic-foot Peet-Grady chamber. Lorol thiocyanate was found to be the most promising material and was further tested in a practical way in a section of a greenhouse. Finally a series of tests was run to show the effect of treatments at weekly intervals. Complete control of the cyclamen mite was obtained by two weekly treatments with 73.7 gm. of a methyl chloride solution containing 10.8 gm. of lorol thiocyanate per 1000 cubic feet of space. The results were confirmed 1 year later. As a dispersing agent methyl chloride appears to be slightly superior to dichlorodifluoromethane. With two treatments no plant injury occurred, but additional treatments caused growth changes characterized by elongated internodes and narrowed leaves. —10–6–43.

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Dr. C. O. Eddy of the Louisiana Agricultural Experiment Station and the University of Louisiana has resigned and accepted a position as Director of Research for the Niagara Sprayer and Chemical Co., Inc., of Middleport, New York. Dr. Eddy assumed his new duties on March 6, 1944 at his new headquarters in Middleport.

The many friends of Dr. Eddy and of the Niagara Company will look forward to the opportunity of cooperating with them in their efforts to extend the service of the Company in the field of insect control.

Edward Wollerman of Columbus, Ohio, writes from overseas. He is attached to the General Hospital, APO 708, San Francisco, but gives no details of his assignment or work. He still wants to receive his Journal regularly, however.

In a letter to the Secretary (January) Major John Wendell Bailey located himself at Fort Custer, Michigan, where he found it cold after his Virginia Home. Major Bailey is concerned with Military Government training.

A Method for Evaluating Treatments for Grape Leafhopper and for Analyzing the Heterogeneity of the Infestation[1,2]

F. Z. Hartzell, *New York Agricultural Experiment Station, Geneva,* and
J. L. Horsfall, *American Cynamid and Chemical Corporation, New York*

The methods used by various investigators for determining the effects of treatment on grape leafhoppers may be grouped chronologically into four classes: (1) examination of foliage to determine efficiency based on an estimation of insect population rather than by actual counting (Slingerland 1904; Hartzell 1910, 1912, 1913; Johnson 1911, 1912); (2) comparison of fruit yields and condition of the foliage (Slingerland, Johnson); (3) determination of sugar and acid in fruit at harvest (Johnson 1912; Hartzell 1913; Van Dine 1923); and (4) direct counts of the insects on the leaves (all workers since about 1923 who give numerical data, at least in the literature examined). The first and fourth methods are direct, the former being rapid and intended to determine whether a treatment is good or worthless. It does not provide precise numerical data but depends largely on the judgment of the workers. The fourth method gives accurate data for each sample but is tedious and time-consuming so the number of samples may easily be limited unless collections are made and preserved for counting much later, in which event the data are not available when most needed. The second and third methods to evaluate treatments are indirect and may not give data that are closely related to the degree of control because the size and quality of the crop depend also on numerous other factors such as soil conditions, fertility, amount of disease, previous yields, etc. The direct and indirect methods actually attempt to answer different questions, namely: How effective is a given treatment in destroying the grape leafhopper? and Does it pay to control this insect with the same treatment? Answers to both questions should be sought but the indirect method should not be used to attempt to answer the question of treatment efficiency and vice versa. Lest we become obsessed with the idea that masses of numerical data are all important and that qualitative statements based on observations are of little value, as some would have us believe, it should be pointed out that the astute observations and comparisons of the earlier workers enabled them to draw valid conclusions as shown by the fact that their recommendations have stood the test of time. It is the intention of the authors of this paper to describe a more rapid and direct method that will give numerical values which will be comparable between different vineyards, between separate years and between various workers. The fact that, until within the past twenty years, population data were not given has created difficulty in making comparisons of the intensity of grape leafhopper infestation during the various outbreaks in a given region or during investigations by various workers in other regions.

The desideratum for studying grape leafhopper control is a uniform method of determining the populations that (1) will meet the requirements of all workers, (2) is fairly rapid, (3) has a practicable degree of accuracy, (4) is sufficiently simple that it can be used by helpers of average intelligence, (5) is adapted to field studies except that certain operations may require shelter from wind, and (6) can be accomplished with simple, inexpensive instruments. The method described in this paper was evolved to meet these requirements in the hope that workers may have a uniform system, thereby making the data of various investigations of the same species comparable.

During an investigation of dusts and sprays for the control of the grape leafhopper, *Erythroneura comes* var. *comes*, in the western New York portion of the Chautauqua and Erie grape belt during late July, 1943, a method was developed for determining populations which is rather rapid, has reasonable accuracy and seems to meet the requirements previously mentioned. The procedure is modeled after that given and used by Glasgow (1939) for determining pea aphid populations. The authors wish to acknowledge

[1] Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 571. December 2, 1943

[2] Eastern Branch Program, 1943.

FIG. 1.—Method of collecting sample showing type of leaf selected.

the help and criticisms of Dr. Glasgow in this investigation. Essentially, the process consists of selecting certain leaves, collecting them in paper bars containing calcium cyanide and determining the total population of the sample by carefully counting the number of insects in an aliquot fraction of the catch and multiplying this number by the denominator of the fraction this portion represents.

SAMPLING.—Before collecting any leaves, a system of sampling should be devised and strictly followed wherever feasible but especially on all plats between which comparisons are to be made. Certain slight modifications of the method which is described may be necessary on other varieties at other seasons or in other regions.

Tests of dusts for the control of grape leafhoppers were made at Fredonia and—12 miles distant—at Silver Creek July 23 to 28, 1943. All vines were Concords, pruned and trained according to the "Chautauqua System." Before any collecting was done a careful study was made to determine the leaves on which the most representative infestation occurred, that is, where adults and the five nymphal instars were present in about the same proportion as the average for all vines. During the latter part of July, the fourth and fifth leaves from the base of each new cane fulfilled this requirement better than older or younger foliage. These also were usually the largest leaves. The type of leaf selected is shown in figure 1. Since vineyards in Chautauqua County generally are divided into sections containing 60 to 80 vines to the row, a detailed description of the procedure followed for sampling in two Silver Creek vineyards about 200 yards apart—is given (Vineyards C and D, Table 1). Two rows well removed from the sides of the plat were used, separate samples being taken from each row. Each sample contained 10 leaves—except for an error in counting in one sample—and included the entire row so that one leaf was taken from one vine in each alternate trellis space.[1] Only fourth or fifth leaves were collected and, for each sample, practically an equal nomber was taken from the upper, middle and lower portions of the vine. Leaves were selected that could be collected without jarring or causing the adults to fly. Each leaf represented the population of the portion of the vine in which the leaf was situated as closely as could be judged by the eye from the degree of injury. The same plan was followed about 18 to 20 hours after dusting and the same vines were used for sampling.

Vineyard A at Fredonia contained 125 vines per row. Samples were taken containing different numbers of leaves in testing the method. The use of 50 leaves in the sample proved too time-consuming to be practical where a large number of samples are desired (Table 1).

COLLECTING.—This was done by using a 25-pound paper bag in which had been placed a small amount—about 2 grams—of granular calcium cyanide to kill the insects and quickly enclosing a leaf (Fig. 1) being careful to prevent jarring until the insects were in the bag. The petiole was then cut. The bag was kept tightly closed until all the insects became stupefied before collecting the next leaf. If the calcium cyanide is enclosed in a porous container previous to being placed in the

[1] The term "trellis space" is used here to designate the part of the wire trellis between 2 adjacent posts. It usually contains 3 vines, as in these Silver Creek vineyards, but occasionally an entire section contains 4 vines between adjacent posts.

bag, removal and handling of the catch is facilitated because the material will not come in contact with the insects. The use of paper bags containing calcium cyanide for sampling grape leafhopper populations has been used for a number of years by the senior author of this paper.

Having collected the samples, they are taken to a suitable place sheltered from the wind, since the insects are light and easily moved by a breeze. A window sash containing a pane of glass 18 by 20 inches was found to be a convenient surface on which to work. Black cloth or paper underneath the glass causes the insects to be more readily seen. Each leaf is held over the glass and carefully swept on both sides by means of a small, dry, "varnish" brush until all the dead leafhoppers are removed and fall to the glass. After all the insects have been brushed from the leaves, the number of leaves is checked since mistakes in counting may occur in taking the sample, as happened in sample 12 (Table 1). The bag is thoroughly shaken over the glass to remove all individuals that fell from the leaves previous to or during removal from the bag. The next step is used if the calcium cyanide is simply shaken loosely into the paper bag without enclosing it in a porous container. Some leafhoppers will be found in the residue and should be separated. This can be done without crushing the insects by lightly and repeatedly drawing the straight edge of a piece of moderately stiff paper in sweeping motions over the material. Light weight paper of the kind used for cheaper grade index cards is very satisfactory. Before removing the cyanide residue it should be carefully examined under a lens for any small nymphs that may remain. These should be counted and the value added to the calculated population of the entire sample later. These details of separation may be avoided if the calcium cyanide is put in a proper container before taking the sample. Another objection to having the calcium cyanide loose in the bag is that it may become mixed with

Table 1.—Variation in grape leafhopper populations between vineyards and in portions of the same vineyard.

Sample Number	Row and Location	Interval Used in Sampling and Combinations	Number of Leaves in Sample	Number of Leafhoppers Per Leaf	Difference in Number Leafhoppers Per Leaf	Samples Compared
		Vineyard A, Fredonia, N. Y.				
1	49, S end	Every 2nd space[1]	10	83.2		
2	49, S end	Duplicate of 1	10	81.2	2.0	1 and 2
3	49, S end	1 and 2 combined	20	82.2		
4	49, entire	Every 4th space	10	115.6	33.4	3 and 4
5	5, S end	Every 2nd space	10	44.8	37.4	3 and 5
6	5, N end	Every 2nd space	20	57.8	13.0	5 and 6
7	5, N and S ends	5 and 6 combined	30	53.5	9.5	7 and 8
8	5, entire	Every 2nd vine	50	63.0	52.6	4 and 8
9	Average of Vineyard A		[2]	69.5	13.9	9 and 10
					47.2	9 and 13
					37.3	9 and 16
		Vineyard B, Fredonia, N. Y. (Adjoined Vineyard A)				
10	9, entire	Adjacent vines	50	83.4	20.4	8 and 10
		Vineyard C, Silver Creek, N. Y.				
11	10, entire	Every 2nd space	10	137.0		
12	20, entire	Every 2nd space	9[3]	96.4	30.6	11 and 12
13	Average of Vineyard C		[2]	116.7	33.3	10 and 13
					9.9	13 and 16
		Vineyard D, Silver Creek, N. Y.				
14	3 entire	Every 2nd space	10	97.5		
15	10 entire	Every 2nd space	10	116.0	18.5	14 and 15
16	Average of Vineyard D		[2]	106.8	23.4	10 and 16

[1] "Space" refers to trellis space described in text.
[2] Not weighted by number of leaves but on average number of leafhoppers per leaf.
[3] Mistake in count while taking sample.

water transpired from the leaves making the separation of the insects difficult.

Usually a considerable number of cast skins will be intermingled with the bodies of the leafhoppers. These can be separated by blowing one's breath across the

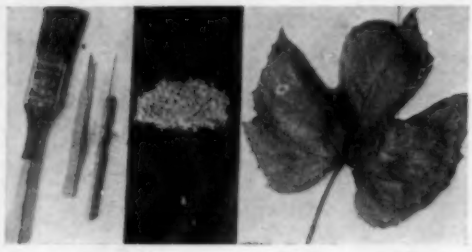

FIG. 2.—Useful tools, 4171 grape leafhoppers from 50 leaves, and medium sized Concord grape leaf.

mass with sufficient force to remove them without including any dead insects. Spiders and undesirable species of insects, if present, should be removed.

COUNTING.—The catch should be very thoroughly mixed to distribute the adults and various nymphal stages uniformly. The entire lot is formed into a rectangular pile having the same depth in all portions except, obviously, at the edges. The rectangle should have a length at least three or four times the width. With a straight-edged knife or a stiff card the rectangle is divided into two equal parts as near as can be estimated. Rectangles are formed of the two halves and compared for accuracy of division. By transferring a few individuals from the larger to the smaller pile inequality can be largely eliminated. One lot is selected for further division and the other discarded. This dichotomous subdivision is continued as far as desired, but the final aliquot should contain not less than 100 individuals, all of which are counted.

The following series results: half, fourth, eighth, sixteenth, etc. The number of divisions can be quickly checked by retaining the discarded fractions on the glass. Multiplying the number in the final aliquot by the denominator of the fraction this represents and adding to this product the number counted in the cyanide residue gives the calculated total population of the sample. A low power lens, preferably 3X or 4X, is usually best adapted for counting. Other instruments which will be found helpful are shown in figure 2. After treatment, if a high degree of control has been obtained, nothing is gained by using the method of subdivision, since the population of a 10-leaf sample will approximate 100.

ACCURACY.—Duplicate samples from the same vines were taken in the first attempts to study the reliability of the method (Samples 1, 2, Table 1). Actual counts of all the individuals in a number of small samples were also made. These studies indicated that 10 leaves constituted an adequate sample for a heavy infestation and that the discrepancies due to aliquot counting were no larger than the variation between duplicate samples from the same vines.

In order to test the accuracy of the method with larger numbers, on July 25, a sample of 50 leaves was taken in vineyard B (Sample 10, Table 1). The catch was divided dichotomously 5 times so that the least fraction which was counted represented one-thirty-second of the total (Fig. 3). All discarded portions as well as the one-thirty-second count fraction (C) were later counted in the laboratory in a petri dish under which was placed a Wolffhuegel counting plate, all properly illuminated. A suitable lens was used and

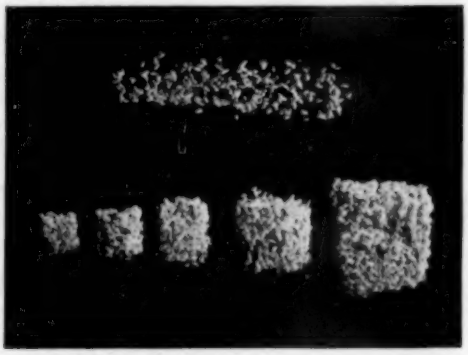

FIG. 3.—Discarded aliquots of one-half to one-thirty-second of sample shown in Fig. 2. One one-thirty-second aliquot spread for counting.

the record kept on a hand tally. Table 2 gives the counts for each fraction as well as the total. The fractions marked "S" were secured by summation of direct counts and also represent the fraction selected for further division.

The effect which the discrepancies, resulting from the use of aliquots, would

have on the per cent control as computed by Abbott's formula (1925) are shown in the last three columns of table 2 for 90, 75 and 50 per cent control. Without using decimals to more than one place, this would mean 8.2, 20.9 and 41.7 survivors per leaf respectively. It will be noted that the discrepancies are very small for 90 per cent control, somewhat larger for 75 and still higher for 50 per cent efficiency. Even with the latter the errors are not sufficient to seriously affect the conclusions.

Even though there are certain errors in this method, the data indicate that if the procedure is closely followed in all samples and care is exercised in sampling, collecting and especially in estimating the size of the various divisions, the error from these sources is surprisingly small; less, in fact, than differences that would be expected from various parts of the same vineyard due to heterogeneity of infestation.

HETEROGENEITY OF INFESTATION.—The infestation within each vineyard appeared to be rather uniform yet a study of table 1 shows that the variation between rows in vineyards A, C and D was very large; also, that in vineyard A, the difference was large in different portions of the same row. The heterogeneity of infestation within each of three vineyards was as great or greater than between the four vineyards. This emphasizes the necessity of extensive sampling in vineyards and the careful selection of only those which are the most homogeneous for grape leafhopper treatments. The method already discussed makes possible the use of a larger number of samples than would be the case if every insect were counted and it is considered just as useful for designing experiments as for the evaluation of treatments. It should be especially valuable in the selection of proper check plats.

Table 2.—Comparison of grape leafhopper populations based on direct counts and calculations (50 leaves taken in the sample).

Fraction	Number Found in Fraction	Total Number Calculated From Fraction	Percentage Discrepancy	Number Per Leaf	Per Cent Control Based on the Following Number of Survivors Per Leaf		
					8.2	20.9	41.7
Total S[1]	4171	4171		83.4	90.2	74.9	50.0
1/2 D[1]	2134	4268	+2.3	85.4	90.4	75.5	51.3
1/2 S	2037	4074	−2.4	81.5	89.9	74.4	48.8
1/4 D	1002	4008	−3.9	80.2	89.8	73.9	48.2
1/4 S	1035	4075	−2.3	80.2	89.8	73.9	48.2
1/8 D	515	4120	−1.2	82.4	90.0	74.6	49.4
1/8 S	520	4160	−0.3	83.2	90.1	74.9	49.9
1/16 D	265	4240	+1.7	84.8	90.3	75.4	50.8
1/16 S	255	4080	−2.2	81.6	90.0	74.4	48.9
1/32 D	128	4096	−1.8	81.9	90.0	74.5	49.1
1/32 C[1]	127	4064	−2.6	81.3	89.9	74.3	48.7
Maximum Discrepancy		163	3.9	3.2	0.4	1.0	1.8
Minimum Discrepancy		11	0.3	0.2	0.1	0	0.6
Average Discrepancy		86	2.1	1.9	0.2	0.5	1.1

[1] S = Part of fraction selected for subdivision, value secured by summation of counts.
D = Part of fraction discarded.
C = Aliquot counted.

SUMMARY.—A special method for determining grape leafhopper populations is described. Essentially, it consists of selecting certain leaves, collecting them, separating the leafhoppers and determining the total catch by counting the number in an aliquot of the sample. Studies indicate that it is rapid, reasonably accurate, sufficiently simple to be used by helpers, adapted to field studies and requires inexpensive equipment.

The errors due to this special manner of counting appear to be no greater than those occurring in duplicate samples from the same vines, and give very small discrepancies in calculating per cent control especially where the efficiency is 75 per cent or greater.

The amount of variation in populations in different parts of the same vineyard was found to be practically as great as between different vineyards. This method described furnishes a quick means for determination of the degree of heterogeneity and is believed to be as important for this purpose as for evaluating treatments. It should be useful in designing experiments. —12-17-43.

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Seedbed and Field Experiments to Control Tobacco Flea Beetles[1]

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Although the tobacco flea beetle, *Epitrix hirtipennis* (Melsh.)[3], is usually considered to inflict its greatest damage to tobacco plants in the seedbed, it is often a serious pest in the tobacco field. In the seedbed many of the young tobacco plants are destroyed in the early stages of growth. Young tobacco plants that are in a wilted condition from having been recently transplated in the field may be killed by a severe attack of flea beetles before they have an opportunity to establish a new root system. The injury to older plants in the field is so evenly distributed that the losses are usually underestimated; however many of the leaves, especially the lower ones, are often severely damaged.

The effectiveness of a number of insecticides in controlling flea beetles on tobacco in the seedbed and in the field has been tested. Beinhart (1932) has suggested the following formula as constituting an effective spray in controlling flea beetles in tobacco seedbeds: 50 gallons of bordeaux (3:3:50 or 4:4:50), 2 pounds of lead arsenate, and 1 pint of *Black Leaf 40*. Chamberlin (1933) has reported good results in field tests on shade-grown tobacco in Georgia and Florida with two to three applications of a mixture of barium fluosilicate, finely-divided infusorial earth, and tobacco dust in the ratio of 8:2:2, respectively. Lacroix (1934) found barium fluosilicate to be slower in action than pyrethrum or rotenone, as regards toxicity to the potato flea bettle on tobacco in the field, but to be more effective in keeping down the population of beetles over an extended period. Dobroscky (1935) obtained very poor control of flea beetles in the field with barium fluosilicate because of lime having been used with it, but a cryolite-talc mixture (40–60 per cent) gave good control. Stanley & Marcovitch (1935) obtained better control of flea beetles in the field with *Dutox* or calcium arsenate than with lead arsenate, natural or synthetic cryolite, paris green, derris, or pyrethrum. In field tests against the tobacco flea beetle in Florida, Chamberlin & Madden (1937) obtained a reduction in percentage of injured leaves of from 75.2 in the controls to 20.5, 31.9, and

[1] Eastern Branch Program, 1943.

[2] The writer wishes to express his sincere appreciation to Dr. Boyd Harshbarger, Statistician, for advice regarding the designs and methods of sampling employed throughout the experiments, and for the analysis of the results.

[3] Identified by Mr. H. S. Barber. According to Mr. Barber and Mr. C. F. W. Muesebeck, the name *E. parvula* (F.) has been misapplied in the literature. The name *E. hirtipennis* (Melsh.) applies to our common tobacco flea beetle here in the north. *E. parvula* (F.) is a subtropical species which comes up into our southern states but apparently does not occur as far north as Virginia.

44.1 per cent with cube dust mixtures containing 1.5, 1.0, and 0.5 per cent rotenone, respectively. Jewett (1937) found that a board frame with a tight covering of tobacco cloth gave a much greater degree of protection to young tobacco plants in the seedbed than any of the insecticides tested; however of the materials tested, the best results were obtained with a barium fluosilicate mixture. Slate (1937) obtained good results with barium fluosilicate, cube root powder, sodium aluminum fluosilicate, and a combination of the first two in field tests on both shade-grown and Havana seed tobacco, although cube root powder was preferable. Allen (1940) has reported on experiments conducted over a period of 5 years, in which derris, cube, barium fluosilicate, calcium arsenate, cryolite, paris green, and lead arsenate were tested against the tobacco flea beetle. His results have shown that the flea beetle can be controlled both in the seedbed and in the field by the use of a dust mixture containing 1.0 per cent rotenone, although the residual toxicity of this material is limited to two or three days. The mixture should be applied at a minimum rate of 0.5 pound per 100 square yards in the seedbed, and at the rate of 8–10 pounds per acre in the field. Further tests by Allen and Shands (1941) have indicated that a cryolite dust mixture containing 80 per cent of sodium fluoaluminate would give better protection over a period of 6 days to young tobacco plants than a cube root dust mixture containing 1.0 per cent of rotenone. They also found that paradichlorobenzene and benzene, when applied at rates and methods known to control blue mold, would not give satisfactory control of flea beetles in seedbeds. Morrill (1941) has reported on field tests conducted during the seasons 1936–40 against the potato flea on shade-grown tobacco. Cube dust containing 1.0 per cent of rotenone was compared with barium fluosilicate, cryolite, cube dust with various supplements, pyrethrum dust, and various sprays formed from different combinations of cube, pyrethrum, and rotenone, with supplements. The most satisfactory control was obtained from a cube-tobacco dust mixture containing 1.0 per cent of rotenone and from an impregnated pyrethrum powder containg 0.5 per cent of adsorbed pyrethrins. More recently, Allen[1] has tested basic copper arsenate as a spray against tobacco hornworms and flea beetles in the field. His results have indicated that 6 pounds of the material to 50 gallons of water, applied at the rate of about 75 gallons per acre, will give rather good residual toxicity to flea beetles, although the initial kill is not as great as with certain other insecticides.

The tobacco seedbed dusting experiment reported herein was conducted with a two-fold purpose; first, to determine the actual sodium fluoaluminate content necessary in a dust to control flea beetles satisfactorily and, second, to determine the relative effectiveness of several materials in protecting young tobacco plants against flea beetles. The field tests were designed to determine the effectiveness of basic copper arsenate as a dust, and the relative effectiveness of several materials, in the control of the tobacco flea beetle on tobacco. Only materials available for use on tobacco during the present emergency period were included in either experiment.

TREATMENTS.—The tobacco seedbed experiment consisted of seven different treatments and one check. The preparations used were *Kryocide*,[2] undiluted; *Kryocide* diluted with *EMTCO # 23*[3] to make dusts containing 70, 50, and 30 per cent of sodium fluoaluminate content; basic copper arsenate ($Cu(CuOH)AsO_4$) about 94 per cent, undiluted; basic copper arsenate diluted with hydrated lime to make a dust containing 50 per cent of active ingredients; and paris green and lead arsenate in the ratio of 1 to 5, respectively.

Two additional treatments were made as emergency measures in tobacco seedbeds owned by tobacco growers. These consisted of *Kryocide* and *Alorco Cryolite*,[4] each diluted with *EMTCO #23* to make dusts containing 70 per cent of sodium fluoaluminate.

The tobacco field experiment consisted of five different treatments and one check. The preparations used were *Genicide*[5] diluted with *EMTCO #23* to make a 2.5

[1] Private communication.

[2] Natural cryolite (90 per cent sodium fluoaluminate) manufactured by the Pennsylvania Salt Company.

[3] A form of talc manufactured by the Eastern Magnesia Talc Company.

[4] A synthetic form of cryolite (85 per cent sodium fluoaluminate) manufactured by the Aluminum Ore Company.

[5] A synthetic organic insecticide (99 per cent dibenzo gamma pyrone and derivatives) manufactured by the General Chemical Company. Commonly known as Xanthone.

per cent dust; *DN DUST D-4*,[1] undiluted; basic copper arsenate diluted with *EMTCO #23* to make a 50 per cent dust; a spray prepared with basic copper arsenate at the rate of 6 pounds per 100 gallons of water, with potash fish-oil soap at the rate of 1:1600 added; and *Alorco Cryolite* diluted with *EMTCO #23* to make a dust containing 70 per cent of sodium fluoaluminate.

PROCEDURE IN SEEDBED EXPERIMENT.—A complete randomized block design was used to test the various treatments. The seedbeds were arranged in pairs at four different locations, with those at two locations seeded later than those at the other two locations. Each treatment was replicated a total of eight times. Each plot was 3 yards in length and approximately 2 yards in width.

The dusts were applied with a plunger type of duster. The drifting of dusts from one plot to another was largely avoided by the use of covers placed over the plot on either side of the one being dusted. All the dusts except the paris green-lead arsenate mixture were applied at the rate of 1.0 pound per 100 square yards of seedbed for the first application, and at the rate of 0.75 pound per 100 square yards for each subsequent application. The paris green-lead arsenate mixture was applied at the rate of 0.5 pound per 100 square yards of seedbed, except for the first and second applications at two locations, when it was applied at rates of 1.0 and 0.75 pound, respectively, per 100 square yards of seedbed.

The time interval between dust applications depended upon the frequency of rains and the amount of insect damage occurring in each block. Three or four applications were made to most of the blocks, although six applications were made to one block and seven to another. In all cases, however, all of the treatments within a given block received the same number of applications.

The results of the dusting experiment were determined when most of the plants had attained a height of from 2 to 5 inches. Three samples were taken from each plot. Randomization was accomplished by making a drawing to scale of the area within a plot, creating subdivisions one foot square, and locating the samples by a chance drawing of numbers. An area 1 foot in width was left as a buffer on all four edges of each plot. For each sample an examination was made of all the tobacco leaves in an area 1 foot square. In a few cases the scarcity of plants made it necessary to examine all the leaves within a plot, except for those in the buffer area. If a leaf had one or more holes in it, produced by flea beetle feeding, it was scored as injured.

The treatments applied as emergency measures in tobacco seedbeds owned by growers were replicated twice at each of two locations. These were arranged according to a latin square design. At one location the plots were 50 square yards in area, and at the other they were 100 square yards in area. Three applications of each material were made at one location and two applications of each at the other. The dusts were applied with a rotary-type of duster at the rate of 1.0 pound per 100 square yards of seedbed. The results were determined as described above, except that four samples were taken from each plot rather than three.

RESULTS OF SEEDBED EXPERIMENT.—The data were analyzed by the Analysis of Variance after having been first reduced to angles (Tables 1 and 2). All treatments were significantly better than no treatment. Undiluted basic copper arsenate was not significantly better than 90 per cent sodium fluoaluminate. There was no significant difference between sodium fluoaluminate at 90, 70, and 50 per cent dilutions, and the 1:5 paris green-lead arsenate mixture; however undiluted basic copper arsenate was significantly better than the average of these four treatments ($F=4.84$ with 1 & 28 degrees of freedom). Sodium fluoaluminate at 30 per cent dilution, and basic copper arsenate at 50 per cent dilution, were the least effective of all the treatments. The interaction of treatments and positions was not significant when the effect of check was removed from the interaction sum of squares.

The data obtained from the treatments applied as emergency measures in tobacco seedbeds owned by growers were similarly analyzed. The average percentages of injured leaves were 7.35 and 10.07 for

[1] An organic insecticide (1.5 per cent dicyclohexylamine dinitro-o-cyclohexylphenate) manufactured by the Dow Chemical Company.

Alorco Cryolite and *Kryocide*, respectively. The difference between the two treatments = P < 2 per cent (Merrington and Thompson, 1943), which is more than is necessary for significance.

Severe injury to the young tobacco plants was obtained in one case (not reported in this paper) when rain followed the application of paris green-lead arsenate mixture at rates of 1.0 and 0.75 pound per 100 square yards of seedbed. No injury resulted during the course of the experiment when it was applied at the rate of 0.5 pound per 100 square yards of seedbed. In no case was injury obtained from the application of any of the other treatments. A slightly more uniform coverage of dust was obtained with the 70 per cent sodium fluoaluminate, the undiluted basic copper arsenate, and the paris green-lead arsenate mixture than with the 50 per cent sodium fluoaluminate and the 50 per cent basic copper arsenate dusts. There was a tendency for the materials in the 90 and 30 per cent sodium fluoaluminate dusts to flow from the duster in non-uniform amounts.

Table 1.—Results of the application of various dusts in tobacco seedbeds for control of the tobacco flea beetle,[1] Chatham, Va., 1943.

Treatment	Injured Leaves (Average)	
	As Angles[2]	As Per Cent
Sodium fluoaluminate, 90%	14.00	5.9
Sodium fluoaluminate, 70%	16.12	7.7
Sodium fluoaluminate, 50%	16.00	7.6
Sodium fluoaluminate, 30%	22.05	14.1
Basic copper arsenate, undiluted	11.60	4.0
Basic copper arsenate, 50%	18.21	9.8
Paris green-lead arsenate, 1:5	16.95	8.5
Check	36.15	34.8

[1] In two blocks several other species of flea beetles were rather abundant.
[2] The standard error of the difference = 2.39.

PROCEDURE IN FIELD EXPERIMENT.—The treatments were arranged according to a complete randomized block design. One set of four replicates was located on the experimental farm, and another set of four replicates on a farm about one-half mile away. A single block was divided into six plots, each of which consisted of four rows of about 19 plants per row. A buffer space, consisting of one row between plots and two plants on either end, was left around each plot. In one location this space was left blank, but in the other the plants were allowed to grow.

The dusts were applied with a rotary-type of duster, while the spray was applied with a 2.5 gallon, compressed-air sprayer. The amount of material applied as a dust was determined by weighing the duster before and after application.

Table 2.—Analysis of variance of the results obtained from the application of various dusts in tobacco seedbeds for control of the tobacco flea beetle, Chatham, Va., 1943.

	D/F	Mean Squares
Locations	3	4,625.87
Treatments	7	1,389.01
Treatments × locations	21	165.02
Pairs	4	456.10
Error	28	68.68
Sampling error	128	20.68
Total	191	

An attempt was made to obtain a uniform coverage of dust and to use about the same amount of each material. However, some variations resulted in the rates of application, as shown by table 3. In the case of the spray the plants were wet until run-off occurred. Four applications were made at intervals of about 2 weeks to all of the plots, except in one case following injury from the previous application. The buffer plants between plots, as well as those surrounding the area of the experiment, were either sprayed or dusted each time an application was made.

The results were determined by making counts of live adult flea beetles on approximately the third day following each application. Six plants were examined from the two inside rows of each plot, exclusive of the two plants on either end of each row. The plants to be examined were determined by a chance drawing of numbers. All leaves, on both upper and lower surfaces, and the stalk of each plant were carefully examined for the presence of live flea beetles.

RESULT OF FIELD EXPERIMENT.—The data were analyzed by the Analysis of Variance after having been first subjected to a mathematical transformation (Tables 4 and 5). *DN Dust D-4* was not significantly better than check. There was no significant difference between basic copper

Table 3.—Approximate amounts of the various materials actually applied in the tobacco field experiment, Chatham, Va., 1943.

Treatment	Average for Eight Replicates (pounds per acre)			
	First application	Second application	Third application	Fourth application
Genicide, 2.5% dust	18.5	19.0[1]	30.2	24.0
DN Dust D-4, undiluted	12.8	16.8	26.3	24.6
Basic copper arsenate, 50% dust	9.2	14.5	25.7	22.4
Basic copper arsenate, spray[2]	Wet to run-off	Wet to run-off	Wet to run-off	Wet to run-off
Sodium fluoaluminate, 70% dust	12.8	25.2	25.2	25.7

[1] Average for seven replicates.
[2] Six pounds per 100 gallons water, with potash fish-oil soap (1:1600) added.

arsenate dust, basic copper arsenate spray, and sodium fluoaluminate dust; however the average of these treatments was significantly better than *Genicide* dust ($F=18.48$ with 1 & 30 degrees of freedom). The interaction of treatments times applications, and the interaction of treatments times locations, for the basic copper arsenate dust, the basic copper arsenate spray, and the sodium fluoaluminate were not significantly different.

Injury to the tobacco leaves was obtained from two applications of *Genicide*. It was used as a 10 per cent dust for the first application at one location, and such severe bronzing of the leaves resulted that the second application was omitted in order to give the plants a chance to recover. For the first application at the other location it was used as a 5 per cent dust. Some bronzing of the leaves resulted although the injury was not as severe as that resulting from the use of the 10 per cent dust. Subsequently, for all applications, the *Genicide* was used as a 2.5 per cent dust. At this dilution the tobacco leaves were not injured as long as the dust was evenly distributed over the plants. No injury resulted from the application of any of the other treatments. A more uniform coverage of dust was obtained with the basic copper arsenate and the *DN-Dust D-4* than with the *Genicide* and the sodium fluoaluminate.

Discussion.—Of the seven dust treatments applied in tobacco seedbeds for control of the tobacco flea beetle, basic copper arsenate undiluted and sodium fluoaluminate at 70 or 50 per cent dilutions were the most promising ones for practical consideration. Basic copper arsenate at 50 per cent dilution and sodium fluoaluminate at 30 per cent dilution were rather ineffective in protecting the young plants from flea beetle injury. Sodium fluoaluminate undiluted and at 30 per

Table 4.—Results of the application of various treatments to tobacco in the field for control of the tobacco flea beetle, Chatham, Va., 1943.

Treatments	Average Live Flea Beetles per Plant	
	$\sqrt{X+0.5}$[1]	Number
Genicide, 2.5% dust	2.300	4.790
DN Dust D-4, undiluted	3.227	9.913
Basic copper arsenate, 50% dust	1.919	3.183
Basic copper arsenate, spray[2]	1.772	2.640
Sodium fluoaluminate, 70% dust	1.852	2.930
Check	3.541	12.039

[1] The standard error of the difference = 0.263.
[2] Six pounds per 100 gallons water, with potash fish-oil soap (1:1600) added.

Table 5.—Analysis of variance of results obtained from the application of various treatments to tobacco in the field for control of the tobacco flea beetle, Chatham, Va., 1943.

	D/F	Mean Squares
Locations	1	111.204
Replicates	6	7.828
Treatments	5	111.859
Locations×treatments	5	6.665
Error (a)	30	1.593
Applications	3	274.647
Applications×locations	3	19.671
Applications×treatments	15	11.280
Applications×locations ×treatments	15	6.312
Error (b)	108	2.229
Sampling error	960	.695
Total	1151	

cent dilution was difficult to apply in uniform amounts. Although the Paris green-lead arsenate mixture is easy to apply in uniform amounts and is rather effective in controlling flea beetles, there is the probability of obtaining injury to the tobacco plants if it is applied at excessive rates or if a wet period follows its application.

In the emergency experiment conducted in tobacco seedbeds *Alorco Cryolite* was significantly more effective in preventing injury from flea beetles than *Kryocide*. However, the former had more of a tendency to pack in the duster and to be more difficult to apply in uniform amounts than the latter. The greater toxicity of *Alorco Cryolite*, therefore, was somewhat offset by its inherently poorer dusting qualities.

Of the five treatments applied to tobacco plants in the field for control of the tobacco flea beetle, the basic copper arsenate spray and the basic copper arsenate dust were the most practical ones for use on a large scale. The sodium fluoaluminate dust at 70 per cent dilution was equally as effective as either of these two treatments, but it had a tendency to pack in the duster and was difficult to apply in uniform amounts. Perhaps the ease of dusting would have been facilitated by the use of natural cryolite rather than synthetic cryolite. The *DN Dust D-4* was ineffective in controlling the tobacco flea beetle. Although *Genicide* gave indication of being rather toxic to the tobacco flea beetle, it was found to injure the tobacco leaves when applied at rates that would give control of this insect.

It would appear that a Latin square design would have been more suitable tanh a randomized block design for the seedbed and field experiments reported in this paper. However, the usual method of preparing tobacco seedbeds will not permit the use of a Latin square design for insecticidal tests. It may be likewise impractical to employ this type of design for field tests in those cases where a large number of treatments are to be applied. In either a seedbed or a field experiment any heterogeneity of insect population could be more satisfactorily eliminated in the resulting analysis if a Latin square design was used. For this reason the author suggests that this type of design be employed when greater accuracy of results is desired and when funds, space, and labor are not important limiting factors.

SUMMARY.—Experiments conducted in tobacco seedbeds and in tobacco fields during the year 1943 for control of the tobacco flea beetle are reported. The plots were arranged according to a complete randomized block design with eight replications of each treatment. The methods of sampling employed are described. The results were analyzed by the Analysis of Variance after having been first subjected to mathematical transformations.

The results of the seedbed experiment were as follows: Undiluted basic copper arsenate was not significantly better than 90 per cent sodium fluoaluminate. There was no significant difference between sodium fluoaluminate at 90, 70, and 50 per cent dilutions, and the 1:5 paris green-lead arsenate mixture; however undiluted basic copper arsenate was significantly better than the average of these four treatments. The least effective of all the treatments were sodium fluoaluminate at 30 per cent dilution and basic copper arsenate at 50 per cent dilution. The interaction of treatments and positions was not significant when the effect of check was removed from the interaction sum of squares. No injury was obtained from the application of any of the treatments, except the Paris green-lead arsenate mixture at rates in excess of 0.5 per 100 square yards of seedbed. More difficulty was experienced in obtaining a uniform coverage of dust with the 90 and 30 per cent sodium fluoaluminate dusts than with any of the other treatments.

Alorco Cryolite and *Kryocide*, each at 70 per cent dilutions, were applied as emergency treatments in tobacco seedbeds. Although the former was significantly better than the latter in protecting the young plants from flea beetle injury, it was more difficult to apply in uniform amounts than the *Kryocide*.

The results of the field experiment were as follows: *DN Dust D-4* was not significantly better than check. There was no significant difference between basic copper arsenate spray, basic copper arsenate dust, and sodium fluoaluminate dust; however the average of these treatments was significantly better than *Genicide*. The interaction of treatments times applications and the interaction of treatments times locations, for basic copper arsenate dust, basic copper arsenate spray, and

sodium fluoaluminate dust were not significant. Bronzing of the tobacco leaves resulted from the application of *Genicide* at rates in excess of 2.5 per cent. No injury resulted from the application of any of the other materials. A more uniform coverage of dust was obtained with the basic copper arsenate and the *DN Dust D-4* than with the *Genicide* and the sodium fluoaluminate—1-18-44.

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The Use of Explosives for the Application of Insecticide Dusts[1]

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The experiments here reported were originally undertaken to explore the possibility of finding a more economical means for the practical or emergency treatment of mature park or forest areas and the like with insecticides, as for control of the gypsy moth, the canker worms, the forest tent caterpillar, the elm leaf beetle, and other insect pests.

The unusual method employed seems to have promise of finding a useful place in many fields of pest control work, including a possible significance for the war effort as in mosquito and malaria control, and in combating certain other insect borne diseases, through attack directed at their specific insect vectors.

CONVENTIONAL INSECT CONTROL PROCEDURES.—The best insect control practice comprises many and diverse procedures; but probably its commonest immediate objective is effectually to contaminate with a highly insoluble insecticide, the food that will be consumed by one life stage or another of the insect to be controlled.

Such an insecticide must be practically insoluble to avoid injury to purposely or incidentally treated plants and to avoid too rapid loss of the poison itself, either of which might occur if the insecticide were soluble in rain water or in dew. Being relatively insoluble, such insecticides are necessarily applied in finely divided form; and many expedients have been devised for placing such insecticide dusts where they may serve their purpose best.

Two general procedures have come to be considered standard for application of the so-called stomach poisons to plants. Usually they are applied either dispersed in water as a spray, or, with or without a dry, inert diluent, as a dust. Each method has its own advantages and disadvantages.

With an insecticide spray, it is possible to add an efficient supplement to act as a

[1] Eastern Branch Program, 1943.

spreader and sticker; and the weight of the liquid carrier makes it possible with sufficient power to overcome resistance of the air and to drive the spray mixture adequate distances from the nozzle. On soft ground, however, or in hilly regions, the extra weight of the liquid spray added to the weight of the mechanism used, may become a prohibitive handicap.

Insecticide dusts have the advantage of lighter weight, both of the insecticide itself, and of the mechanism used; but the use of a sticker supplement has not been found generally practicable.

Large scale dusting has usually been done either by some form of power duster which discharges the finely pulverized, dry insecticide in a blast of air, or by airplanes in which case the insecticide dust is fed into the propeller blast.

With air encountering air, the blast from a standard power duster can not carry the insecticide dust to a sufficient height for practical control on well established shade and forest trees; and in mountainous regions where landing fields are few and usually remote, airplane dusting has not been found practical for general use.

FOREST SPRAYING DIFFICULT AND EXPENSIVE.—As a result, in large scale operations like maintenance of the gypsy moth barrier zone, large spray outfits have been the main reliance, the handicaps of weight and terrain being overcome as follows:

Here, the huge portable spray outfit capable of delivering a pressure of 1000 pounds per square inch is stationed near a stream or pond providing an adequate supply of water, and heavy, one-inch, high pressure hose is carried into the forest, sometimes for a distance of two miles or more. Then, with lateral leads the forest is sprayed thoroughly for some distance on each side as the hose is withdrawn section by section toward the power plant. By repeating this procedure, the infested forest area is covered strip by strip. Obviously this is an expensive process. Expensive in capital investment and maintenance, and expensive in labor cost.

CONVENTIONAL DUSTING NOT PRACTICABLE.—Dusting by conventional means, however, has not been found a practicable alternative. Much of the barrier zone is mountainous, with airplane landing and reloading fields few and remote. As a consequence, dusting from airplanes would be extra hazardous, if not physically impossible. Power dusters operating from the ground could not reach the tree tops, even if they were not excluded by the vegetation and topography.

APPLICATION DUSTS BY EXPLOSIVES.—As still another possible alternative, the very unconventional expedient of using explosives for the application of insecticide dusts appeared worthy of exploration, the idea being to dispense entirely with cumbersome machinery, and in suitable manner and proportions to bring together propulsive power and insecticide in relatively small units, much as powder and shot are brought together in fowling ammunition.

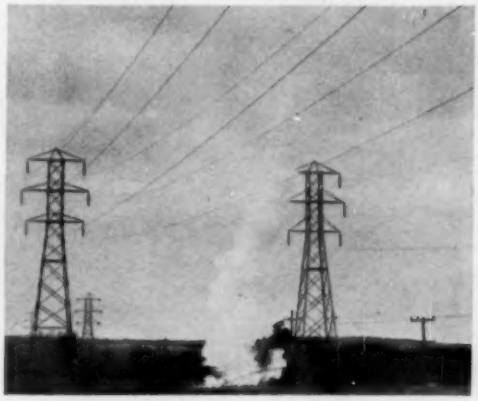

FIG. 1.—More than 100 feet high, and still going. An 8×10 inch rolled paper mortar charged with 4 ounces of *Grade A, 4F* powder and 4 pounds of dust.

Aided by a light breeze this shot gave fair coverage an eighth of a mile away.

At first, the cooperation of a local fireworks manufacturer was enlisted in order to operate under his explosives permit. From him it was learned that some group in California, of which his record had been lost, had several years before employed this man to make for their use a small number of fireworks-like bombs charged with an insecticide. The results of their experiments apparently were not published. These earlier devices were provided with two explosive charges, one to drive an insecticide bearing bomb into the air where it was exploded by the second charge. This device, however, was appar-

ently too complicated and too expensive for practical use. Obviously, to be practical, this type of procedure must be kept as simple and as inexpensive as possible.

Working toward that end, it soon was found that a charge of insecticide dust could be fired directly from a mortar on the ground and dispersed by the resulting agitation of the air, sufficiently high to meet any practical requirement.

In this preliminary work mortars of several types and dimensions were tried. One was a rolled paper mortar, 8 inches in diameter and 10 inches deep, with side walls a quarter of an inch thick, which had been salvaged from some fireworks display. This mortar was fired repeatedly without showing evidence of failure. Another mortar tried was of iron, 6 inches in diameter and 18 inches deep. A third type of mortar was made from 4-inch gas pipe short nipples four inches long threaded at both ends, and with one end closed by a standard 4-inch pipe cap.

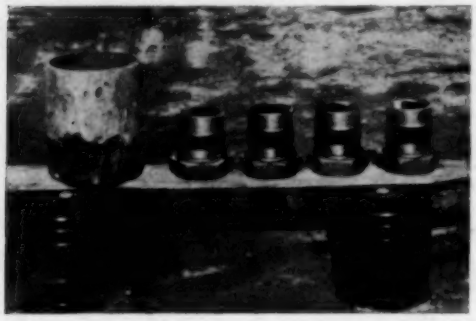

FIG. 2.—Two of the various mortars used.
The largest, a rolled paper mortar 8 inches in diameter by 10 inches deep had been salvaged from some fireworks display. This was fired repeatedly without showing any sign of failure.
The others are 4 inch gas pipe short nipples, closed at one end by a 4 inch pipe cap.

With the quantity of explosive varied in accordance with dimensions of the mortar, quantity of insecticide, and the lift desired, the mortars were charged in the following manner:

1. A charge of *Grade A, 4F* rifle powder was placed on the bottom of the mortar. A similar type of cheaper blasting powder might have served as well.

2. A safe length of fuse was added, one end placed in the powder, and the other end allowed to trail over the edge of the mortar.

3. A disc of heavy cardboard was then placed over the powder so as to hold the inner end of the fuse securely in place, and to equalize the first thrust of the burning powder.

4. A square piece of heavy kraft paper was next placed in the mortar so as to rest smoothly on the cardboard disc at the bottom, and carefully folded at the sides so as to line the mortar smoothly to well above the charge of insecticide.

5. The charge of insecticide was finally placed in the mortar within the paper lining, which was then folded loosely over the top.

Without the paper lining, the drag of the insecticide dust against the sides of the mortar appeared to interfere with the proper lift and mushrooming of the charge.

With suitably balanced charges arranged in this manner, it should be possible to secure almost any lift and dispersion of the insecticide that may be desired. In these preliminary tests, excellent coverage was obtained at distances much greater than one hundred feet from the mortar.

When carried by a light breeze the agitation of the air has continued, and good coverage has been observed at distances of more than two hundred yards.

PREFERRED MORTAR DESIGN.—The iron mortars described, while excellent for experimental work, are heavy and expensive. Because of their cost, they must be retrieved after use; and their weight adds to the cost of operation when they are placed and gathered up.

In practice it would be best to use a rolled and cemented paper mortar that would be lighter and cheaper, and so not worth recovering after use. The bottom of course should be so attached as to hold securely against the thrust of the explosion. The built up wall need not exceed three-sixteenths to one-fourth inch in thickness.

FIRE HAZARD.—Any fire hazard which might result from the use of untreated paper and cardboard can be avoided by infiltration with a high melting, non-combustible, chlorinated hydrocarbon, such as the clorinated naphthalene "Halowax" and the like. In this or some other appropriate manner, each unit should be made both fireproof in use, and waterproof if exposed to rain or dew before being fired.

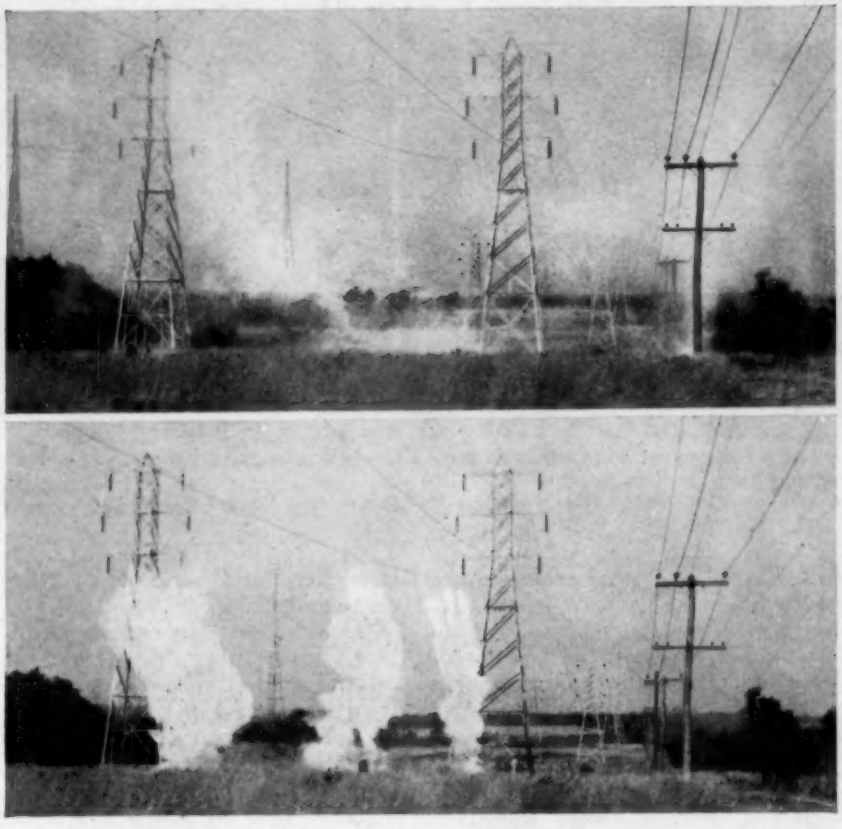

FIG. 3.—Above:—Three 4 inch iron mortars, each charged with 3 ounces of *Grade A, 4F* powder and 3 pounds of dust, fired at approximately one second intervals. Approximately 3 minutes after firing. Showing continued lift and dispersion resulting from the turbulence of air produced by the three explosions. Below:—Three 4 inch iron mortars, each charged with 3 ounces of *Grade A, 4F* powder and 3 pounds of dust. Shots fired at approximately one second intervals, showing form of lift and beginning spread.

CONTEMPLATED METHOD OF USE.—In a park or forest area that is to be dusted, the charged mortars should be placed the day before, each unit as already indicated in a waterproof enclosure, but with a bit of the fuse easily accessible.

It has been suggested that a safety fuse be employed, tipped at the free end with a safety-match-like composition which may be set ablaze with a touch of a safety-match box, or with a special safety-match-like chemical igniter.

Then in early morning while the leaves are still wet with dew, while the air is still, and while conditions are most favorable for dusting operations, or likewise just following an adequate fall of rain, men would be assigned, one to each row of the previously placed mortars, and each would pass rapidly along his row igniting each fuse before passing on to the next.

With properly designed charges in suitably placed mortars of appropriate size and with correct allowance for wind drift if any, a forest area could be thoroughly dusted with an insecticide or fungicide dust very quickly, under the most favorable conditions, and apparently at a very moderate cost as compared with the cost of methods now in current use.

The drive of the many explosions will set up a complicated system of air currents and eddies which should assure thorough coverage of the foliage both on the upper and the under sides of the leaves from undergrowth to forest crown.

POSSIBLE USEFULNESS IN WAR AREAS.—Many war areas offer special problems in the control of insect borne disease, where this method apparently might be

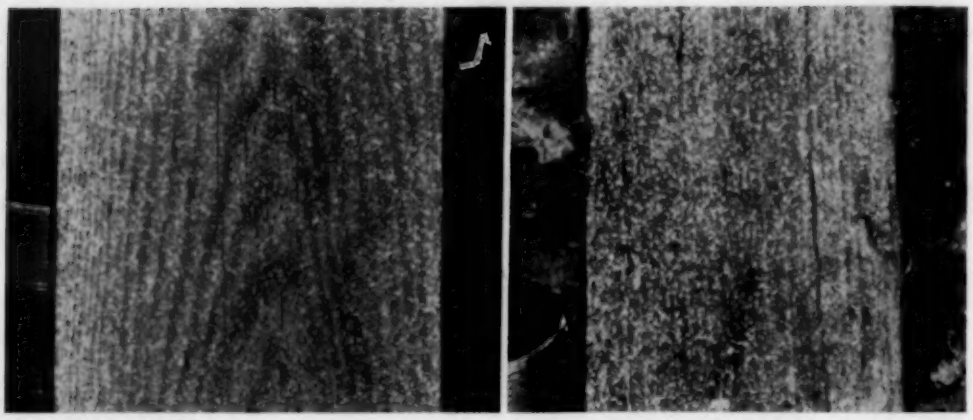

FIG. 4.—Left:—Coverage at 50 feet from a single 4 inch iron mortar, charged with 3 ounces of *Grade A, 4F* powder and 3 pounds of dust.

Right:—Coverage at 100 feet from a single 4 inch iron mortar, charged with 3 ounces of *Grade A, 4F* powder and 3 pounds of dust.

used with advantage. Some examples are cited in the following paragraphs.

In his administrative report for 1934 the Surgeon General for the Colony of Trinidad and Tobago, that officer records a very special type of malaria control problem that is presented by the breeding habits of *Anopheles bellator*. Dr. D. P. Curry, formerly Assistant Chief Health Officer of the Panama Canal, reports a similar problem due to the breeding habits of *Anopheles neivai* and other species.

In Trinidad and elsewhere where *Theobroma cacao*, or the dwarfish shade-requiring cocoa or chocolate tree is cultivated extensively, the needed shade is provided by interplanting with several species of *Erythrina*, known also as Immortelle, and Madre del Cacao trees.

The immortelle tree grows 80 to 100 feet high; and it provides support for several bromeliad epiphytes which grow attached to the branches from 40 to 60 and even to 80 feet above the ground. These air-plant relatives of the pineapple and of the Spanish moss of our South have water-holding receptacles at the bases of the leaves; and it is in such small but innumerable, and relatively inaccessible accumulations of water that *Anopheles bellator* in Trinidad, and some related malaria-carrying mosquitoes of other tropical regions may develop.

On Trinidad, where we have an important air base, huge Fitz-Henry Guptil forest and shade tree spray outfits are being tried for control of this important vector of malaria. Both there, and elsewhere where heavy spray machinery can not be provided, it would seem that the use of explosives in the manner here described might provide a practical means of treating the mosquito-breeding water not only with anti-anopheline arsenicals, but possibly even with mono-hydrated copper sulphate dust sufficient to kill the mosquito-harboring air plants themselves.

CONCLUSION.—A highly unconventional insect control procedure has been described. Only pioneer work has been done so far. The procedure, however, seems to have much promise of finding a useful place in many fields of pest control, not only in times of peace, but also in war zones and training areas. The procedure probably could be quickly developed for emergency use under war conditions; much work remains to be done, however, to establish its real place in our general peace-time armament against insect pests and plant diseases.—1-14-44.

Oriental Fruit Moth Parasite Liberations and Surveys[1,2]

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A survey of parasitism of Oriental fruit moth larvae feeding in peach twigs in orchards of New Jersey was resumed in 1937. Somewhat similar surveys have been made by Driggers (1930) and Stearns (1928) in New Jersey peach orchards in previous years. It was planned to continue the surveys for a number of years to determine (1) what species of parasites were present and most important in the various peach growing areas of the state and (2) whether there was a relationship between degree of parasitism of the first two broods of twig feeding larvae and the fruit infestation at harvest. It was believed that such a study would also yield information that would enable us to better utilize the native parasites known to attack the Oriental fruit moth.

Some of the data obtained from the studies during the years 1937 to 1940 inclusive have been published (Driggers 1940, 1941). The surveys covering those years showed that the parasite *Macrocentrus ancylivorus* Rohr. was the most numerous parasite of twig feeding larvae in orchards of central and southern New Jersey, accounting for over 90 per cent of all parasites reared from twig feeding larvae in these orchards. This parasite was not found in orchards of northern New Jersey except in one locality in Hunterdon County where it had been liberated several years previous to 1937. Another parasite, *Glypta rufiscutellaris* Cres., which appeared for the most part on second and third brood larvae, was the most numerous parasite in orchards of northern New Jersey.

These findings led to colonization experiments with *M. ancylivorus* in three widely separated localities in northern New Jersey (Driggers 1941). These investigations showed that *M. ancylivorus* adults liberated at the rate of 300 to 400 per acre on second brood larvae became established and built up on third brood to a point where it became the most important parasite, displacing *Glypta rufiscutellaris* for first place. It was shown also in these studies that *M. ancylivorus* spread several miles from the orchard of liberation to other orchards during the season of liberation. Lastly, it was shown that *M. ancylivorus* would winter over one season in these northern New Jersey orchards, although not to the same extent as in orchards of southern New Jersey.

The parasite surveys were continued in orchards of north, central and southern New Jersey during 1941, 1942 and 1943. A continuation of the work seemed advisable to determine if *M. ancylivorus* continued to parasitize a high percentage of larvae in orchards of central and southern New Jersey year after year. Data on the length of time *M. ancylivorus* would remain effective in the liberation orchards of northern New Jersey were also desired. The results of the three years' survey are set forth in tables 1, 2 and 3.

A study of the data in tables 1, 2 and 3 will show that *Macrocentrus ancylivorus* Rohr, was the most numerous parasite in orchards of central and southern New Jersey (Middlesex, Burlington, Canden, Gloucester, Atlantic and Cumberland) during the three year period 1941 to 1943 inclusive. Reference to an earlier paper (Driggers 1941) will show that this parasite has held first place in these orchards since 1937. In the Morris county orchard (Tables 1 and 2) surveys were made from 1937 to 1942 inclusive. No *M. ancylivorus* have been liberated in or near this orchard and no specimens of this parasite have been found there.

Data from two orchards in northern New Jersey, one in Warren County and one in Somerset County, show what happens to *Macrocentrus ancylivorus* after it has become established from liberated colonies. Colonies of *M. ancylivorus* were liberated in the Somerset orchards (Nos. 25, 12 and 10 in tables 1, 2, and 3) in 1939 and again in 1941. As a result of these liberations *M. ancylivorus* proved to be the most numerous larval parasite in this orchard in 1939, 1940 and 1941. No further liberations were made in this orchard in 1942 and 1943. During 1942 and 1943, *M. ancylivorus* dropped to the position of a minor parasite in this orchard and *Glypta* sp. regained its former dominance. Seven larval collections were made in this

[1] Journal Series paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology.
[2] Eastern Branch Program, 1943.

orchard in 1942 from May 27 to July 20 to cover first and second broods. From an uncounted number of collected tips, a total of 121 fruit moths, 7 *M. ancylivorus*, 77 *Glypta* sp. and 73 miscellaneous parasites were reared. During 1943, in five collection periods extending from May 22 to July 9, 49 fruit moths, 1 *M. ancylivorus*,

Table 1.—Percentage parasitism of first and second brood Oriental fruit moth larvae feeding in peach twigs and the principal parasite in 27 orchards in eleven counties in New Jersey in 1941.

Orchard No.	County	Percentage Parasitism[1] First Brood	Second Brood
	Southern New Jersey		
1	Burlington	16.7	62.4
2	Burlington	40.6	79.3
3	Burlington	25.0	49.4
4	Burlington	48.6	60.3
5	Burlington	14.6	55.7
6	Burlington	35.6	69.3
7	Camden	6.2	80.6
8	Camden	9.4	42.0
9	Camden	57.5	70.8
10	Gloucester	44.8	82.6
11	Gloucester	40.0	61.4
12	Gloucester	30.7	72.0
13	Gloucester	70.0	77.3
14	Atlantic	55.6	79.8
15	Cumberland	19.2	81.1
16	Cumberland	19.2	55.6
17	Cumberland	27.3	63.2
	Central New Jersey		
18	Middlesex	48.5	82.5
19	Middlesex		56.4
	Northern New Jersey		
20	Hunterdon	26.4	87.9
21	Hunterdon	30.6	67.5
22	Morris	5.6	75.8
23	Warren	2.2	85.6
24	Warren	4.4	78.5
25	Somerset	7.1	79.8
26	Somerset	2.1	81.1
27	Bergen	23.0	96.6

[1] *Macrocentrus ancylivorus* was the principal parasite except in orchards 22 and 24 where *Glypta* sp. was dominant.

32 *Glypta* sp. and 20 miscellaneous parasites were reared.

In the Warren County orchard (orchards No. 23, 13 and 11 in tables 1, 2 and 3) colonies of *Macrocentrus ancylivorus* were liberated in 1940 and again in 1941. Surveys made the three years previously showed no *M. ancylivorus* present before liberation as was the case in the Somerset County orchard. Heavy parasitism by *M. ancylivorus* was recorded on second and third brood larvae in this orchard in

Table 2.—Percentage parasitism of first and second brood Oriental fruit moth larvae feeding in peach twigs and the principal parasite in 15 orchards in seven counties in New Jersey in 1942.

Orchard No.	County	Percentage Parasitism[1] First Brood	Second Brood
1	Burlington	21.0	74.0
2	Burlington	14.7	
3	Camden	23.3	70.0
4	Camden	12.2	84.8
5	Gloucester	27.0	80.0
6	Gloucester	53.0	88.2
7	Gloucester	56.0	76.0
8	Gloucester	10.0	50.0
9	Middlesex	25.0	
10	Middlesex	14.0	75.0
11	Middlesex		74.6
12	Somerset	2.3	66.3
13	Warren	17.6	60.0
14	Warren	2.1	61.0
15	Morris	0.0	

[1] *Macrocentrus ancylivorus* was the principal parasite except in orchards 12 and 14 where *Glypta* sp. was dominant.

1940 and 1941. No parasites were liberated in this orchard in 1942 and 1943. The trend of parasitism during these two years was similar to the trend in the Somerset County orchard. In 1943 six separate twig larval collections were made in the Warren County orchard from May 28 to July 9. From the collected larvae we reared 55 fruit moths, no *M. ancylivorus*, 20 *Glypta* sp. and 8 miscellaneous parasites.

Table 3.—Percentage parasitism of first and second brood Oriental fruit moth larvae feeding in peach twigs and the principal parasite in 12 orchards in seven counties in New Jersey in 1943.

Orchard No.	County	Percentage Parasitism[1] First Brood	Second Brood
1	Burlington	14.3	81.7
2	Burlington	5.5	25.8
3	Camden	37.1	76.0
4	Camden	18.0	13.0
5	Gloucester	29.6	67.7
6	Gloucester	21.4	65.1
7	Gloucester	52.4	43.7
8	Gloucester	10.0	38.3
9	Middlesex	33.0	16.4
10	Somerset	11.4	73.1
11	Warren	19.6	44.6
12	Warren	2.0	15.7

[1] *Macrocentrus ancylivorus* was the principal parasite except in orchards 10, 11 and 12 where *Glypta* sp. was dominant.

The data from these two orchards indicate that *M. ancylivorus* will become established and winter over for one year in certain northern New Jersey orchards, but will eventually disappear unless reintroduced from time to time. This is in contrast to orchards of central and southern New Jersey where *M. ancylivorus* has been recovered year after year on both first and second broods of larvae in a number of orchards over a period of years.

THE ROLE OF ALTERNATE HOSTS.—It is interesting to speculate on why *Macrocentrus ancylivorus* Rohr. persists year after year in peach orchards of central and southern New Jersey but is absent or of minor importance in orchards of northern New Jersey. The answer, in part at least, appears to be the presence of alternate hosts in or near orchards of central and southern New Jersey and the absence of such alternate hosts in northern New Jersey. The strawberry leaf roller, *Ancylis comptana* (Froel.), is known to be an alternate host of *M. ancylivorus* on which the parasite will overwinter readily. Surverys have shown that the strawberry leaf roller is generally distributed wherever strawberries are grown in central and southern New Jersey. The leaf roller, on the other hand, is rarely found in strawberry plantings in northern New Jersey. In fact, efforts to establish the leaf roller in strawberry plantings in northern New Jersey have failed. During 1939, 1940 and 1941 when *M. ancylivorus* was being colonized in the Warren and Somerset County orchards large numbers of strawberry leaf roller adults reared from strawberry leaves collected in southern New Jersey were allowed to escape from cages located near strawberry plantings. Only an occasional leaf roller larva could be collected following these liberations and, the following summer, none could be found.

There is a possibility that other alternate hosts of *Macrocentrus ancylivorus* occur in central and southern New Jersey. Pepper & Driggers (1934) reported rearing *M. ancylivorus* from an unidentified lepidopterous larva found in smartweed in an orchard in Monmouth County. During the spring and fall of 1941 extensive collections of smartweed were made in peach orchards in all sections of the state in an effort to confirm and extend this observation. *M. ancylivorus* was reared from smartweed collected in Monmouth, Burlington and Gloucester Counties. *Macrocentrus delicatus*, a related species, was reared from these three counties and from Middlesex, Camden, Atlantic and Cumberland. All of these counties are in central and southern New Jersey. Neither species of *Macrocentrus* was reared from smartweek collected in orchards of northern New Jersey. The alternate host in smartweed is probably *Aristotelia disconotella* Cham. This species, together with the European corn borer, *Pyrausta nubilalis* (Hbn.), was reared in large numbers from smartweed collected in orchards in central and southern New Jersey.

SUMMARY.—Surveys of the parasitism of Oriental fruit moth larvae feeding in peach twigs were extended over a period of seven years. *Macrocentrus ancylivorus* Rohr. proved to be the most numerous larval parasite attacking twig feeding larvae in orchards of central and southern New Jersey. This parasite was not found except where artificially introduced in orchards of northern New Jersey. Another species, *Glypta rufiscutellaris*, proved to be dominant in the northern area. When introduced in northern New Jersey on second brood fruit moth larvae, *M. ancylivorus* built up on second and third brood to become the dominant species during a single season. The parasite wintered over one season but by the end of the second season it had practically disappeared. The absence of alternate hosts of *M. ancylivorus* in northern New Jersey is suggested as one of the reasons for its failure to maintain itself in the northern peach growing areas of the state.—2-12-44.

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Population Studies of the European Spruce Sawfly in Maine as Affected by Natural Enemies[1,2]

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The European spruce sawfly, *Gilpinia hercyniae* Htg., was first discovered on the American continent in 1930 in the Gaspé Peninsula of Canada. In a few years it had increased and spread into new territory at an alarming rate. By 1937, it was given first rank among the insect enemies of the northeastern spruce forests by informed foresters and entomologists. In Maine spruce is the most valuable commercial tree, and serious damage appeared to be imminent. This paper presents results of work on the European spruce sawfly in Maine covering a five-year period from 1939 to 1943.

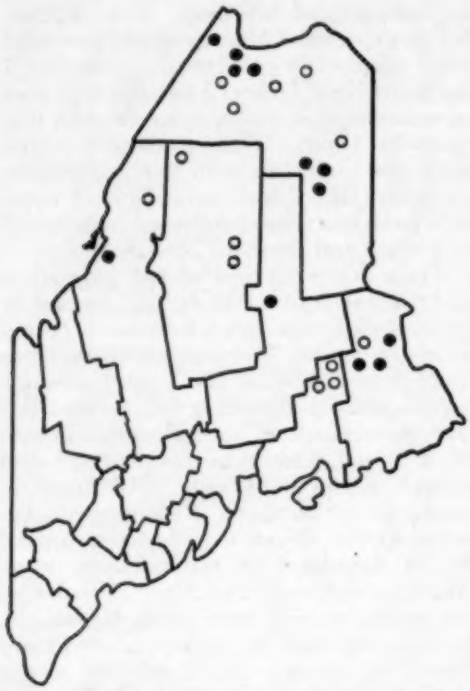

Fig. 1.—Location of European spruce sawfly plots in Maine—1939 plots, solid dots; 1940 plots, circles

Twenty-five plots were selected during 1939 and 1940 to cover the different topographical regions of the state and to represent the different types of spruce growth (Fig. 1). Although it has not been possible to gather data from all plots every year, an average of over 15 plots annually has been under observation.

For purposes of conciseness and also because the data are believed to be representative of spruce sawfly conditions for much of the state, results are given for only two of these plots. The two plots selected are in the north central part of Maine, Plot A being approximately 35 miles south of Plot B.

Plot A on Township 9, Range 5 was burned over about 60 years ago. At the present time the stand is composed of about 50 per cent softwood species of spruce, balsam fir and white pine, with the spruce predominating. Poplar and birch species make up most of the hardwood portion of the stand. The soil is thin and underlaid with gravel and rocks. Rate of tree growth has been relatively slow. On only a few spots on the ground is there a heavy cover of moss.

Heavy defoliation by the European spruce sawfly occurred during 1939 on Plot A, and by early August most of the spruce trees had lost 50 to 70 per cent of their old needles. Frass from the feeding larvae covered the ground in a layer in places to a depth of one-half inch. An average of 121.8 larvae per catch was secured that year while beating larvae from spruce on a cloth mat 48 inches by 54 inches. Since 1939, a very marked decline in abundance of larvae has occurred on Plot A. During the summer of 1943, only 1.2 larvae per catch were taken by beating. This was the lowest number during the five years (Table 1).

A similar sharp decrease in numbers of sound cocoons was found during the same period of time on Plot A. A total of 20 sound cocoons per square foot was gathered during this five-year period. Thirty-nine per cent of these sound cocoons were present in 1939; 52.5 per cent in 1940; and only 1 per cent in 1943 (Table 2).

[1] This study was undertaken and made financially possible through the help and encouragement of the following committee representing timberland owners of Maine: Mr. L. J. Freedman, Penobscot Development Company, Great Works, Maine; Mr. C. M. Hutchins, Dead River Company, Bangor, Maine; Mr. William Hilton, Great Northern Paper Company, Bangor, Maine; Mr. Jerome Lynch, Eastern Corporation, Brewer, Maine; Mr. George D. Bearce, Maine Seaboard Paper Company, Bucksport, Maine; Mr. E. R. Hendrick, International Paper Company, Chisholm, Maine.

[2] Eastern Branch Program, 1943.

On Plot B in Township 14, Range 6, the forest stand is composed almost entirely of softwood species. Here also spruce is the predominant species, and balsam fir, white pine, birch and poplar make up decreasing percentages of the forest composition. Tree growth has been relatively rapid due to a fertile forest soil of loam and clay. A cover of sphagnum moss of a considerable depth is characteristic under the trees.

Feeding by larvae of the European spruce sawfly was observed to be heavy during the summer of 1937 and to a less degree in 1938 and 1939 on Plot B. By the latter year defoliation of the spruce varied from 10 to 50 percent in this area. Frass under defoliated trees was deep from the feeding of larvae over a period of several years.

Table 1.—Abundance of larvae from beaten or jarred trees.

	Township 9, Range 5 Plot A		Township 14, Range 6 Plot B	
Year	Larvae per Catch	Per Cent	Larvae per Catch	Per Cent
1939	*121.8*	—	—	—
1940	4.1	18.9	1.3	9.8
1941	13.5	62.3	2.1	15.7
1942	2.9	13.3	9.1	68.4
1943	1.2	5.5	0.8	6.1
Total	21.7	100.0	13.3	100.0

No data by beating of larvae were taken on Plot B until 1940, but it is known that larvae were abundant in 1937 and somewhat less abundant in 1938 and 1939. Since 1940, the numbers taken have been low, except in 1942 when 9.1 larvae per catch were obtained. Since 1939, no noticeable defoliation has been observed and practically no frass has accumulated (Table 1). A marked reduction in sound cocoons per square foot during the last five years also has occurred on Plot B; similar in most respects to that found on Plot A.

It seems apparent that one or more unfavorable factors during the last five years has become at least temporarily established in the environment of the European spruce sawfly and brought about its present low infestation. Since the sawfly in only limited areas in Maine had reached numbers large enough to consume as much as 50 to 70 per cent of its possible food supply before the decline set in, it is evident that lack of food was not among the unfavorable factors.

Table 2.—Sound cocoons per square foot.

	Township 9, Range 5 Plot A		Township 14, Range 6 Plot B	
Year	Number	Per Cent	Number	Per Cent
1939	7.8	39.0	10.0	46.1
1940	10.5	52.5	8.4	38.7
1941	0.95	4.8	2.4	11.0
1942	0.55	2.7	0.6	2.8
1943	0.2	1.0	0.3	1.4
Total	20.00	100.0	21.7	100.0

Balch (1936), among others, has reported a number of important native natural enemies which attack the cocoons. Among the natural enemies of importance in Maine are shrews, mice and squirrels, which tear open the cocoons to remove healthy larvae. Also, Carabid adults and larvae and Elaterid larvae bore into the cocoons and destroy the insect. The destruction of the sawfly by mammalian and insect predators varies from year to year and also between different areas. The total percentage of sound cocoons destroyed by these enemies seldom is greater than 45 to 50 per cent or lower than 25 to 30 per cent. No definite increase in damage to the sawfly by the predators was noticed on Plot A or Plot B during the years, 1939 to 1943 (Table 3).

The liberation of large numbers of colonies of the cocoon parasite, *Microplectron fuscipennis*, from 1937 to 1942 throughout the spruce timber areas of Maine by the Maine State Forest Service constitutes

Table 3.—Classification in percentage of square foot samples.

Year	Sound	Emerged	Destroyed by Native Predators	Dead from Disease and Unknown Causes	Destroyed by Microplectron
		Township 9, Range 5—Plot A			
1939	35.9	30.4	31.8	1.8	—
1940	26.3	43.3	22.2	5.0	3.2
1941	3.6	51.3	32.4	11.1	1.6
1942	2.1	51.6	33.7	12.0	0.5
1943	0.9	55.8	34.2	9.1	—
		Township 14, Range 6—Plot B			
1940	33.8	24.9	30.6	8.3	2.2
1941	13.7	31.3	43.2	11.4	0.65
1942	2.9	40.9	41.7	14.3	0.05
1943	1.5	46.1	39.5	12.9	—

Table 4.—Sound cocoons parasitized by *Microplectron.*

Year	Township 9, Range 5 Plot A	Township 14, Range 6 Plot B
	Per Cent	Per Cent
1940	13.5	6.2
1941	34.5	5.3
1942	7.6	2.5
1943	1.5	0.8

one new factor introduced by man into the environment of the European spruce sawfly. *Microplectron fuscipennis* multiplies at a much more rapid rate than its host, by having three or more generations per season, while the European spruce sawfly has one generation in the north, and two generations in the south of Maine. In outdoor cage conditions under dense spruce shade one generation of *Microplectron* was reared in 26 days during July in 1940. Three generations between June 3 and October 4 under similar conditions were observed the same summer.

To arrive at a sound basis for determining the effectiveness of an insect parasite of a destructive species is often difficult, and investigators are not always in agreement as to methods.

Peirson (1941) has reported that in Maine more than 37 million *Microplectron* were reared and liberated during 1939 and 113 million during 1940. Releases of *M. fuscipennis* were first made on Plot A, in Township 9, Range 5 in 1938 and on Plot B, in Township 14, Range 6 in 1935. Additional releases were made during a period of 3 or 4 years on both areas.

In table 4 is given the percentage of sound cocoons parasitized by *Microplectron* from 1940 to 1943. No recoveries of the parasite were made in 1939 although adequate sampling was made on Plot A, but none on Plot B. The highest per cent of parasitism observed at any time was 43.7 per cent on Plot A in 1941 among the sound cocoons taken in the square foot samples. Of all of the sound cocoons gathered by different methods on Plot A in 1941, the average parasitism was 34.5 per cent.

Parasitism over the 4-year period was higher on Plot A than on Plot B. It is possible the amount and depth of moss on the ground may account for the difference between the two plots. On Plot A, with the higher degree of parasitism it was observed that less moss and a shallower depth of litter occurred under the trees than on Plot B. Observations made in 1939 with marked cocoons buried at measured depths in forest litter, demonstrated that the parasite has difficulty in finding sound cocoons which are at levels greater than 1 to 1.5 inches below the surface. The European spruce sawfly frequently spins its cocoons in moss at a depth of 2 or 3 inches. In table 3 the percentage of cocoons attacked by *Microplectron* is based upon the total number of cocoons taken in square foot samples. Since the old, broken and lifeless cocoons of the sawfly remain for a number of years in the litter, estimates of percentages of parasitism based upon sound cocoons seems more accurate.

The lower percentage of parasitism during 1942 and 1943 on both plots is likely due to a scarcity of sound cocoons, and as a result, the population of the parasite was reduced. In a number of areas of low infestation of the sawfly, *Microplectron* has been able to maintain itself during the last two years. This seems to indicate that if at some future date the sawfly infestation becomes abundant, *M. fuscipennis* will be present and should promptly exert a marked influence on the infestation of the sawfly.

WILT DISEASE OF LARVAE.—In October of 1939 a few diseased larvae were found on Plot A. By September of 1940

Table 5.—Disease among larvae from beaten or jarred trees.

Date	Township 9, Range 5 Plot A	Township 14, Range 6 Plot B
	Per Cent	Per Cent
1939 July 11	0.0	0.0
1940 Sept. 2–11	37.9	48.9
1941 July 20–31	33.9	11.8
1941 Aug. 12–28	51.2	39.2
1942 July 13–16	2.2	0.5
1942 Aug. 5–8	32.0	46.2
1942 Aug. 24–25	63.0	98.0
1943 July 13–14	7.7	0.0
1943 Aug. 25–26	5.8	23.5
1943 Sept. 27–28	3.4	12.5

the disease was common on both plots. Counts made among the larvae beaten from trees gave over 35 per cent of diseased larvae in the two plots during 1940. Percentages of diseased larvae as high as 60 per cent to 90 per cent or over were found in 1941 and 1942, especially toward the end of the season.

The disease as observed in Maine apparently is the same as that found in other New England states and Canada (Peirson 1941; Wood 1941). A larva with the disease can usually be identified as having been attacked by the wilt disease by its abnormal appearance. The diseased larva first loses its normal green color along the mid-dorsal line of the abdomen. The color turns to a yellowish green. Later the whole insect becomes yellowish-green and then almost black. The body is shrivelled and wrinkled especially at the time of the darkening in color. The contents of the body ooze out and frequently cause the insect to adhere to the twigs of the tree. It seems likely that in some instances the bodies of diseased larvae remain on the spruce from one summer to the next. During 1941 and 1942 the disease was not in evidence among the larvae until about July 15 to 25. During both years, however, a higher and higher per cent of the larvae were diseased as the season progressed, at least until the end of August, when observations were discontinued. The disease is more prevalent among older larvae in the 5th or 6th instar than on larvae younger than the 5th instar.

Table 6.—Comparison of larvae, July and August 1941.
(Jarred or beaten larvae collected on cloth under trees)

	Per Cent of All Larvae Diseased	Per Cent of Young Larvae Diseased	Per Cent Larvae in 5th and 6th Instar, Diseased
	Township 9, Range 5—Plot A		
July	33.9	9.5	72.1
August	51.2	41.3	74.8
	Township 14, Range 6—Plot B		
July	11.8	6.2	33.3
August	39.2	27.2	60.1

However, on the younger larvae the percentage of disease is greater in August than it is in July (Table 6). It was observed that the disease attacks the young larvae more frequently as the percentage of mortality becomes greater. For example during August in 1942 very few larvae as mature as the 5th instar were seen, because the disease was causing such high mortality during the earlier instars.

Table 7.—Disease among larvae caught in cloth trays.

Year	Township 9, Range 5 Plot A		Township 14, Range 6 Plot B	
	Total Sawflies per Tray	Per Cent Diseased	Total Sawflies per Tray	Per Cent Diseased
1940	8.7	70.0	3.4	39.0
1941	24.4	98.2	4.0	71.5
1942	1.2	95.7	11.3	99.0
1943	0.5	20.0	0.2	0.0

During 1943 the percentage of diseased larvae remained low throughout the season—in no case were as high as 25 per cent of the larvae found diseased. The small numbers of diseased larvae may have been due to the climatic conditions of the year. On the other hand, it is possible the disease was reaching the end of its cycle and was dying out from lack of host material. The numbers of larvae were many times lower in 1943 than during the three previous years.

By means of cloth trays approximately 30 inches square and arranged with a barrier band of tanglefoot to prevent escape of the insect, a study was made of the larvae which dropped from the trees during the season (Table 7). The results secured appeared to confirm and strengthen the data obtained from the beating and jarring of larvae on a mat. The percentage of diseased larvae caught on cloth trays was between 70 per cent and 99 per cent on both Plot A and Plot B during 1941 and 1942. A much lower percentage of mortality was observed on both plots in 1943.

CONCLUSIONS.—The European spruce sawfly increasingly threatened severe injury to spruce forests in Maine from 1935 to 1940, reached a high level of population about 1939, and has declined rapidly in 1941, 1942 and 1943.

During the years of this study a number of important native rodent and insect predators attacked from 20 per cent to 50 per cent of the cocoons of the sawfly, but seldom appeared to constitute a per-

manent check at a time when an epidemic of the sawfly was imminent.

The cocoon parasite, *Microplectron fuscipennis*, an introduction from Europe, when established in the spruce forests of Maine, was capable of a high percentage of parasitism of the cocoons under favorable conditions. Cocoons of the European spruce sawfly spun in deep litter and moss were not parasitized by *M. fuscipennis* as frequently as cocoons near the surface.

A wilt disease of the European spruce sawfly was widespread in Maine from 1940 to 1942 and frequently caused a high percentage of mortality to the larvae. The disease was generally prevalent in areas of both high and low population of the larvae and appears to have been an important factor in the decline of the European spruce sawfly.—1-14-44.

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Fluorine Compounds as Alternates for Rotenone-Bearing Dusts[1]

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The continued shortages of both rotenone-bearing roots and pyrethrum flowers have emphasized the need for suitable alternate materials for use on vegetable crops. In addition to the development of entirely new insecticides, there is the possibility of more extensive use of materials already available. In this group of materials the fluorine compounds seemed to offer the most promise, especially since they were available in quantities sufficient to allow a large extension of uses. The compounds most suited for foliage application are the natural and synthetic cryolites, and barium fluosilicate. These have been used successfully for a number of years to control a variety of insects including many vegetable pests. Carter & Busbey (1939) have compiled a bibliography of fluorine compounds used as insecticides. Shepard (1939) presented a review of fluorine compounds, stressing their use as substitutes for arsenicals. Eddy (1940, 1942) has reported successful use of both barium fluosilicate and cryolite on several vegetable pests. Marcovitch & Stanley (1942) have prepared a general summary of uses of the common fluorine compounds.

In Connecticut barium fluosilicate has been found satisfactory for control of the Mexican bean beetle (Turner & Friend 1935) and for flea beetles attacking vegetables, including potatoes (Turner 1940). It has been in use commercially to control flea beetles on potatoes for several years. The residue problem on beans was solved by confining applications to plants before the pods formed.

During 1943 several tests of cryolite dusts were made on chewing insects attacking vegetable crops. The objectives were: (1) to determine the dosage of cryolite required to equal the degree of control with commonly-used dosages of rotenone in derris dust; (2) to test the effect of diluents used with cryolite in dusts; and (3) to compare the toxicities of natural and synthetic cryolite.

METHODS.—Four concentrations of each material were used in each test. All tests were made on small plots of from ten to twenty feet of row, and treatment was with hand dusters. At least three replicates were used in each test, and all treatments were randomized in blocks. Except where noted, the applications were made in accordance with standard schedules suggested to growers to control the pests involved.

The characteristics of the materials must be taken into account in comparative tests such as these. Cryolite is a relatively stable inorganic compound. Derris root contains a number of toxic organic

[1] Eastern Branch Program, 1943.

Table 1.—Control of Mexican bean beetle comparing dusts containing rotenone and cryolite.

DERRIS DUST		CRYOLITE DUSTS			
			Natural		Synthetic
			Diluent		
Per Cent Rotenone	Reduction in Larvae	Per Cent Cryolite	Clay	Pyrophyllite	Diluent Pyrophyllite
			Reduction in Larvae		
0.5	99.8%	50	99.8%	98.1%	92.0%
.25	98.8	25	89.3	96.3	98.6
.125	96.9	12.5	88.5	90.7	92.9
.0625	80.5	6.25	79.8	88.8	48.9

compounds, the most important being rotenone. Rotenone itself is affected by light, as shown by Jones *et al.* (1933). Wisecup & Reed (1938) have reported a loss of toxicity of cube powder when exposed to weathering, although some toxicity remained after five days. Todd (1938) found that derris did not protect bean foliage in the field beyond seven days of exposure. There is no information indicating that residues of cryolite lose toxicity in such a manner. This being the case, the interval between treatments, and between treatments and time of taking results, might have an important bearing on the comparative effectiveness of the two materials. Long intervals would favor cryolite and short ones rotenone.

The use of four concentrations of each material allows a comparison of dosage for equal control. The data obtained can be plotted as dosage response curves thus facilitating comparison at the concentration used and, by interpolation and extrapolation, of other concentrations as well.

The results of the tests reported here were highly variable. This was due in part to lack of rainfall during the entire season and particularly after June 15. Fitting curves mathematically for such data would not reduce the variability or add to the precision of comparisons. For this reason comparisons have been made on the basis of the original data.

MEXICAN BEAN BEETLE.—Tendergreen snap beans planted early in July were dusted August 4 and 16. Results were obtained by counting the larvae surviving on August 25. Ten plants were taken from each plot for this count. Results are presented in table 1, the percentage reduction being calculated by the difference in numbers of larvae on treated and untreated plants. The average number of larvae on an untreated plant was twenty. While there are some large variations in results at different dosages, it is evident that the most concentrated cryolite dust used (50 per cent cryolite) was on the average no more effective than 0.25 per cent rotenone in derris dust.

In three of the four concentrations of natural cryolite dust the pyrophyllite diluent produced a higher mortality than the clay. At the highest concentration clay was more effective. This discrepancy prevents any definite conclusion as to diluents, but does indicate at least a tendency in favor of pyrophyllite.

Likewise variations in results between natural and synthetic cryolites prevent accurate comparison, but both were effective.

CABBAGE WORMS.—Late cabbage set in July was dusted August 18 and 31 and September 20. Some imported cabbage worms were present, but most of the damage was caused by the cabbage looper. Results were obtained October 6 by use of a scoring system. Heads with no damage to the head or four loose leaves around it were rated 0. Those with slight feeding on four loose leaves were rated 1; with severe damage to the loose leaves but none to the head, 2. Slight feeding on the head itself was 3 and severe damage 4. The highest damage possible was 4, In calculating the results, the average score was subtracted from the total possible and divided by the total to provide a percentage "control." Pyrophyllite was used as the diluent in all cases. The results are given in table 2 and show that cryolite at as low as 12.5 per cent concentration was more effective than derris dust of 0.5 per cent rotenone content. Both the interval

Table 2.—Control of cabbage worms using derris and cryolite dusts.

Derris		Natural Cryolite		Synthetic Cryolite	
Rotenone Content	Control	Strength	Per Cent Control	Strength	Per Cent Control
0.5%	59.2%	50%	66.4%	50%	80.0%
.25	43.5	25	69.2	25	86.7
.125	46.7	12.5	73.3	12.5	64.2
.0625	33.6	6.25	60.0	6.25	42.5
No treatment	22.5	No treatment	22.5	No treatment	22.5

between treatments and between the last treatment and the date results were taken favored cryolite rather than derris.

As between synthetic and natural cryolites, the variation was large, with synthetic appearing superior at high concentration and natural more effective at the low strengths.

Flea Beetles.—Irish Cobbler potatoes were dusted at weekly intervals during June (on June 2, 4, 8, 14, 21 and 28). The June 4 treatment was a replacement of the first application which was followed by rain. Results were obtained on June 25 by the scoring system described previously (Turner 1943). The results are summarized in table 3.

Table 3.—Control of potato flea beetles on Irish Cobbler potatoes.

Derris Dust (Clay Diluent)		Natural Cryolite (Clay Diluent)	
Rotenone	Control	Cryolite	Control
2.0%	83.3%	50%	78.7%
1.0	80.1	25	76.3
.5	82.5	12.5	79.4
.25	68.7	6.25	68.7
No treatment	58.4	No treatment	58.4

Variations in control between dosages in both series makes comparison difficult. However, it is apparent that the cryolite at higher dosages provides only slightly less control than rotenone at 0.5 and 1 per cent. The weekly schedule used here tends to favor the derris dust since the treatments were applied much more frequently than in commercial treatments.

European Corn Borer on Potato.—The flea beetle experiment just described afforded an opportunity to obtain information on control of the European corn borer attacking potatoes. The infestation was very heavy and the treatments were timed to cover the period of hatching of corn borer eggs. The results were obtained on July 20 by counting the number of entrance or exit holes left by migrating larvae and the broken branches. They have been reduced to terms of control by comparison with untreated check plants. Results are given in table 4.

The cryolite provided a high degree of protection and 50 per cent cryolite was more effective than 1 per cent rotenone. The plots treated with the higher dosages of both materials were very conspicuous in the field late in July. The untreated plants had many broken branches and actually died much earlier than those in which borers were controlled. Since this same treatment controls both flea beetles and the Colorado potato beetle in addition to the European corn borer, it should be of practical value in protecting potatoes from the corn borer, which is not abundant enough each season to justify special treatment.

Discussion and Summary.—(1) With the number of treatments, interval between treatments and relative time of taking results as described above, the comparison of dosages of cryolite and rotenone in derris dust was as follows: (a) for the Mexican bean beetle, 50 per cent cryolite was no more effective than 0.25 per cent rotenone; (b) for cabbage worms (chiefly loopers) 12.5 per cent cryolite was more effective than 0.5 per cent rotenone; (c) for flea beetles on potatoes, cryolite at 50 per cent was slightly less effective than

Table 4.—Control of European corn borer on Irish Cobbler potatoes.

Derris-Clay		Natural Cryolite-Clay	
Rotenone	Control	Cryolite	Control
2.0%	92.5%	50%	90.1%
1.0	73.1	25	66.9
.5	54.1	12.5	70.2
.25	45.8	6.25	25.2

rotenone at 0.5 or 1.0 per cent; (d) for control of the European corn borer on potatoes, 50 per cent cryolite was more effective than 1 per cent rotenone. The interval between treatments favored cryolite in the test on cabbage, and rotenone in the case of potatoes.

(2) In the one test involving diluents, results were variable but in three out of four cases pyrophyllite was more effective than clay.

(3) There were large variations in results of tests comparing natural and synthetic cryolites. The results certainly show no consistent difference between the two types.—1-14-44.

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The Breeding of the Salt-Marsh Mosquito in Midwestern States[1]

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In September and October of 1941, the writer, in response to a number of complaints regarding abundance of mosquitoes which were interfering with production in defense industries at and near Evansville, Indiana, investigated the situation. Larvae and adults were taken, and the offending species was found to be *Aëdes sollicitans* (Walker).

Although far removed from tidal salt water and in a section of the country where the breeding of a salt-marsh species of mosquito would hardly be expected, it was found that there were two sources of salt water in the area: salt water wells and oil wells.

SALT WATER WELLS.—These were dug to supply water for a number of swimming pools in and around Evansville. All but one of these swimming pools had either been closed by the state Board of Health for sanitary reasons or had run dry. The one pool in operation was in Burdette Park. It had been in operation since 1926. The well supplying it was pumped continually for about three months during each summer, and delivered approximately 100 gallons per minute. The overflow from this pool was carried in an open riprapped ditch into Bolton Lake. The sides of this lake were fairly steep and were riprapped; there was very little likelihood that this lake would overflow its banks. From Bolton Lake, the water made its way over a spillway into a rather long and narrow, rectangular shaped pond. The sides of this pond were also riprapped, but the ends were not. Both ends, but particularly the lower, were marshy in nature.

From the lower end of the pond, the water made its way into a shallow open ditch approximately 1000 feet long. It was apparent that the water level in the pond

[1] Eastern Branch Program, 1943.

and in the ditch was variable and influenced by the operation of the swimming pool and by rainfall. During periods of little rainfall the water level receded, and following heavy rains, the level rose so that more or less of the marshy areas at each end of the pond and the banks of the ditch were flooded. The ditch led into Bayou Creek.

The presence of salt water and the irregular flooding and recession of the water in the lower pond and the ditch leading from it established conditions suitable for the breeding of *Aëdes sollicitans*. Although it is not known how fertilized female adults got there to start with, *A. sollicitans* larvae were found in the marsh at the lower end of the pond and in the ditch leading from it. They were particularly abundant at the junction of the ditch and Bayou Creek. No breeding was found in Bayou Creek.

Table 1.—Salt content and pH of water from Bolton Lake to Bayou Creek.

Sampling Point	pH	Chlorides (p.p.m.)
Bolton Lake	7.6	10,200
Overflow between Bolton Lake and Lower Pond	8.0	7,200
Lower Pond	8.3	7,300
Marsh at end of Lower Pond	7.2	6,800
Ditch leading from Lower Pond to Bayou Creek	8.2	8,800
Junction of Ditch and Bayou Creek	7.5	5,800
Bayou Creek	7.4	2,600

The chlorides content and the pH of the water, from Bolton Lake to Bayou Creek, are presented in table 1.

Oil Wells.—The oil wells discharged, in a large number of cases, a mixture of oil and salt water. Separation of these took place in tanks and then the salt water, usually still containing some oil, discharged into open pits (basic sediment pits). Here, under ordinary operating conditions, the water slowly seeped back into the ground.

In other cases, however, where the pits had not been constructed large enough to handle the volume of salt water, an underdrain had been built into the pits. These underdrains carried off the excess water into bullies, where it was discharged, forming small salt streams. Most of these streams did not connect with any permanent streams or other bodies of water but finally seeped into the ground.

At some oil wells basic sediment pits were not used and the mixture of salt water and oil was discharged directly into surface ditches which connected with other ditches or streams. The oil was gradually dissipated, and at some distance from the point of discharge the salt water appeared to be free from oil. The water in one of these ditches contained 7200 p.p.m. chlorides and its pH was 8.0. No *A. sollicitans* breeding was found, but it was believed that a potential hazard did exist.

Salt Marsh Mosquito Breeding in Illinois.—During 1940, 1941 and 1942 there were infestations of *Aëdes sollicitans* at Centralia, Illinois. The 1941 infestation was so severe that almost all normal outdoor activities in this city and its environs ceased, and the story was distributed by one of the press associations and carried by newspapers in various sections of the country. The writer had an opportunity to inspect the Centralia area in 1941, and further details concerning this and the other outbreaks discussed below were supplied in personal communications from W. J. Downer, acting Chief Sanitary Engineer and J. D. Williams, Mosquito Control Engineer, of the Illinois Department of Public Health. The Centralia infestation was caused by very heavy *sollicitans* breeding in a swamp of approximately 125 acres. Salt water from oil wells flowed about one-half mile in open ditches and discharged into the swamp. The salt as it left the wells contained between 30,000 and 50,000 p.p.m. chlorides. The concentration of chlorides in the swamp varied considerably, but the water was very salty to taste at any point. All fresh water vegetation in the swamp was killed. *A. sollicitans* was also found to be breeding in some fresh water areas about one-half mile from the swamp, although not in nearly so great numbers.

At Dupo, Illinois, a similar condition existed where salt water from oil wells was discharged into a swampy area. Large numbers of *Aëdes sollicitans* and of *A. dorsalis* (Meigen) were reported from this area.

A surprisingly high degree of tolerance to acid water by *Aëdes sollicitans* larvae is reported by Downer and Williams. At

White City, two miles west of Mt. Olive, Illinois, *A. sollicitans* larvae were plentiful at all points in a pond into which flowed the acid mine waste from a shaft coal mine. Only *A. sollicitans* larvae were found in this pond. There was very little emergent vegetation and the water level was reasonably constant. The acidity of the water was 850 p.p.m. and the pH was 2.7.

It is also interesting to note that *Aëdes solicitans* was taken in a light trap operated near Marion, Illinois, and that both *A. sollicitans* and *A. dorsalis* were taken in a light trap at Savannah, Illinois.

PREVIOUS RECORDS.—Chandler (1921) reported taking *Aëdes sollicitans* at Carbondale, Illinois, in 1918 and at Herrin, Illinois, in 1920. This general area is known to be underlain with salt. Carpenter (1941) reported that both *A. sollicitans* and *A. taeniorphynchus* (Wied.) were collected from the LePile Creek and DeLutre Bayou areas in Union County and the Snow Hill Community in Ouachita County in Arkansas since 1937. He reported the two species were common in areas affected by the dumping of salt water from oil wells into creeks and lowland areas. The salt water was carried by overflows into depressions along the streams for several miles and evaporation of the water provided sufficient concentration of salt in the soil over large areas to provide excellent conditions for the development of the larvae of these species in temporary pools formed by rains.

King *et al.* (1942) report that M. A. Barber found *Aëdes sollicitans* in a brackish swamp near Artesia, Eddy County, New Mexico, in 1938.

Adams & Gordon (1943) list Jefferson Barracks, Creve Coer Lake, and Kimmswick, all in Missouri, and Dupo, Illinois, as places where they collected *Aëdes sollicitans*. Dr. Robert Matheson has in his collection a considerable number of adult females of this species which were taken at Syracuse, New York and two females from Wellton, Juma County, Arizona. The specimens taken at Syracuse were breeding in water from salt wells. Dr. Matheson also states that larvae of *Aëdes cantator*, Coq. another salt water breeder, were taken from saline pools both at Syracuse and Ithaca, New York.

H. H. Stage recalls that when the El Dorado Oil Field in Southern Arkansas first came in, *A. sollicitans* were taken soon afterward from some of the salt water pools pumped from the oil wells. The fact that *A. sollicitans* were found there soon after the accumulation of a small amount of salt water aroused considerable interest at the time. F. C. Bishopp collected *A. sollicitans* from East St. Louis, Illinois, in 1937.

Rozeboom (1942) reported that "salt water pools, which form at the edges of the Great Salt Plains near Cherokee [Oklahoma], are inhabited by *Aëdes sollicitans* and *A. dorsalis* . . . . Only one collection was made in salt water pools but there are many salt plains and springs in the northwestern area of Oklahoma, and these two species should be quite widespread."

SUMMARY.—The common salt-marsh mosquito of the east coast, *Aëdes sollicitans*, was found to be breeding abundantly in and near Evansville, Indiana, and near Centralia and Dupo, Illinois. At each of these places this species was found breeding in areas which were intermittently flooded with salt water from swimming pools or oil wells. In one case, *A. sollicitans* larvae were taken from a pond into which flowed the acid mine waste from a shaft coal mine.—11-29-43.

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Cpl. Reynold G. Dahms writes from Orlando, Florida (January) where he is located in the AAF Tactical Center.

J. H. Girardeau, Jr., of McRae, Georgia was in Australia according to latest reports from Mrs. Girardeau.

A Low Rotenone Content *Derris malaccensis* Dust Effective Against Certain Vegetable Pests[1,2]

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In the period from 1935 to the outbreak of the present war rotenone bearing dusts have proved to be a popular and efficient insecticide for the control of many truck crop and garden insects. The great popularity of this insecticide was forceably brought home when the Japanese invasion of the major derris producing countries of the Far East resulted in a serious reduction of rotenone supplies and brought about Federal restrictions which limited the use of rotenone bearing dusts for the control of insects attacking our more essential agricultural crops. The general shortage, as well as the limitation orders on the use of rotenone made it desirable to search for alternate materials which might be used in general agricultural insecticides. It was brought to the attention of the writers that there was a sizable tonnage of *Derris malaccensis* which contained only a trace of rotenone available in this country. Due to its low rotenone content this product has little or no possible use except as an agricultural insecticide. Mr. Franklin C. Nelson of Stanco Incorporated, Bayway, N. J. suggested that work be undertaken to determine the efficiency of this product as an agricultural insecticide and has been instrumental in obtaining the materials used in the foregoing experiments.

HISTORICAL.—The literature on the plant sources, insecticidal values and uses and analysis of rotenone have been admirably surveyed by Roark (1942, 1943), Campbell (1932) and Jones (1942) in recent publications. A review of this literature shows, that in most instances, entomological workers have used the rotenone content as a criterion of expressing the insecticidal effectiveness of tested materials. Although early investigators showed that derris and cube extracts contained toxic constituents other than rotenone, only a limited amount of work on the insecticidal effectiveness of these other toxic constituents appears in the literature.

A review of the literature indicates that *Derris malaccensis* is one of two species of derris that are cultivated in the Malay Peninsula. According to Roark (1941), "The roots of this species contain little or no rotenone but average 19 per cent or more ether extract." Beside rotenone the following compounds have been found in derris root: levodeguelin, levo-alpha toxicarol, elliptone, sumatrol and malaccol. Of the known constituents of derris root only rotenone and levodeguelin exhibit any marked toxicity to insects. The toxicity of various constituents of derris root to *Aphis rumicis* has been studied by Davidson (1930) who reports the following order of toxicity: rotenone, deguelin, tephrosin, toxicarol. Shepard & Campbell (1932) found the same order of toxicity in stomach poison tests against the silkworm by the leaf sandwich method. In both these tests rotenone was considerably more toxic than other constituents and toxicarol exhibited but little toxicity. As the rotenone content of derris and cube preparations did not adequately express their toxicity to insects, the Goodhue (1936) colorimetric method of determining the rotenone and deguelin content has been suggested as a more suitable criterion. Jones (1935) found the Goodhue color test to give a better measure of toxicity than the rotenone or total extractive contents in tests against houseflies. Goodhue and Haller (1939) in studies on the determination of deguelin in derris and cube, states, "The high toxicity to insects of the noncrystalline portion of derris and cube extracts, coupled with a generally low deguelin content, suggests the presence of other unidentified compounds that contribute to the toxicity."

Arant (1942) worked with rotenone bearing insecticides in which the toxic principles were derived from several sources, derris, timbo, cube and *Tephrosia*. In tests with 10 or more species of insects, he concluded that the rotenone content was inadequate to express the insecticidal value of a rotenone-bearing product and emphasized the importance of the Goodhue rotenone-deguelin value as a supplementary expression.

English investigators and Tattersfield and his co-workers (1935) in particular

[1] Journal Series Paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Entomology.
[2] Eastern Branch Program, 1943.

have devoted considerable time to the problem of the evaluation of rotenone containing plants. These workers using known samples of *Derris elliptica*, *D. malaccensis* and Sumatra type root have studied the chemical and insecticidal properties of these species of derris root and have concluded that, "The determination of purified rotenone, ether extract, dehydro compounds, ether soluble resin after potash treatment, and the rotenone plus deguelin concentrates are each shown to be inadequate as a means of assessing the relative insecticidal activity of the Sumatra type, *D. malaccensis* and *D. elliptica* roots."

FIELD EXPERIMENTS.—The results reported in this paper, were taken from a series of field tests undertaken in 1943, in which a large number of materials were tested as possible alternates to replace part or all of the rotenone in standard agricultural insecticides. The insecticidal value of *D. malaccensis* has been obtained by comparing the insecticidal activity of dusts containing this material with dusts containing 0.4 per cent and 0.5 per cent rotenone from *D. elliptica* and *Lonchocarpus* sp., and other currently recommended or commercially available insecticide dusts. *D. malaccensis* dust was compared wity 0.4 per cent and 0.5 per cent rotenone dusts, made from *D. elliptica* and *Lonchocarpus* sp. and other dusts against the Mexican bean beetle, *Epilachna varivestis* Muls., cabbage worm, *Pieris rapae* L., *Autographa brassicae* Riley, *Plutella maculipennis* Curt., European corn borer, *Pyrausta nubilalis* Hbn., and the potato aphid, *Macrosiphum solanifolii* Ashm.

All experiments were conducted, on commercial plantings of the various crops, under field conditions.

The following formulae give the composition and rotenone analysis of the dust mixtures used.[1]

	Per cent
1. *Derris malaccensis* powder	20.0
Pyrax ABB	80.0
Total Ether Extractives	2.94
Rotenone	Trace
2. *Derris elliptica* powder	9.10
Pyrax ABB	90.90
Total Ether Extractives	1.13
Rotenone	0.50
3. Cube (*Lonchocarpus* sp.)	8.62
Pyrax ABB	91.38
Total Ether Extractives	1.37
Rotenone	0.50
4. Cube (*Lonchocarpus* sp.)	7.00
Pyrax ABB	93.00
Total Ether Extractives	1.12
Rotenone	0.40
5. Cube (*Lonchocarpus* sp.)	7.00
Lethane 60	2.00
Pyrax ABB	91.00
Total Ether Extractives	1.12
Rotenone	0.40
6. *Black Leaf 155*	28.56
Talc	47.44
Sulfur	25.00
Nicotine	4.00

[1] Formula (1), except that used in the corn borer experiment, and formula (2) were prepared by Stanco Inc., while all others were prepared in the laboratory by the writers.

MEXICAN BEAN BEETLE.—Two experiments were conducted on Mexican bean beetle, using duplicated field plots of 6 rows, 30 feet long. In the first experiment the varieties of Bountiful and Plentiful stringbeans were used while the second experiment consisted of the Plentiful variety only. The dusts were applied with a Root rotary continuous action hand duster equipped with a single nozzle

Table 1.—Experiments with Mexican bean beetle. Averages of duplicated samples showing number of live larvae and adults and reduction in population 3 and 5 days after dust applications.

Dusts	No. Per 36 Ft. of×Row		Per Cent Reduction	
	Larvae	Adults	Larvae	Adults
First Experiment—Records taken 3 days after dusting.				
(1)[1] Trace Rotenone (*D. malaccensis*)	1		98	
(2) 0.5% Rotenone (*D. elliptica*)	0		100	
(4) 0.4% Rotenone (*Cube*)	2		96	
(5) 0.4% Rotenone (*Cube*)+2% *Lethane*	6		88	
Check	53		—	
Second Experiment—Records taken 5 days after dusting.				
(1) Trace Rotenone (*D. malaccensis*)	0	2	100	95
(4) 0.4% Rotenone (*Cube*)	3	6	99	71
(5) 0.4% Rotenone (*Cube*)+2% *Lethane*	9	6	97	71
Check	316	21		

[1] Numbers in parentheses ( ) refer to dust formulae.

directed upward at an angle of about 45 degrees. Each side of each row was dusted, disregarding the coverage of the upper side of the leaves. All plots were dusted by the same person walking at a "standard" pace with the duster adjustment constant for all materials which gave an application rate of approximately 25 pounds per acre. The materials were applied in the first and second experiments on July 10 and August 11 and records were taken on July 13 and August 16 respectively. Records were made by counting all Mexican bean beetles on 6 samples of 3 linear feet of row in each of the two replicates. The results are presented in table 1.

ment. A predusting examination showed that the infestation was uniform throughout the field. Before the counts were made a preliminary examination showed that the worm population of each plant in a respective plot was fairly constant. With this information at hand five plants from each replicate were examined thoroughly and the number of larvae of each species was recorded. These data are presented in table 2.

The data from this experiment were not as extensive as might be desired due to the fact that only a single dust application was made and the lack of help prevented further sampling. It should be noted, however, that several other insecticidal materials were tested in this experiment and served as a basis for evaluating the materials listed in the table. These plots were, however, followed carefully after the dust applications and with the exception of the rotenone-Lethane plot and the checks, worm injury was slight at the time of harvest. The check plots in the second experiment were a total loss due to worm injury.

Table 2.—Experiments with 3 species of cabbage worms. Averages of duplicate samples showing number of live larvae and reduction in larval population 96 hours after dust application.

Dusts	Imported		Looper		Diamond Back	
	No. of Larvae	Per Cent Reduction	No. of Larvae	Per Cent Reduction	No. of Larvae	Per Cent Reduction
First Experiment—Flat Dutch—nearly mature.						
(1) Trace Rotenone (*D. malaccensis*)	0	100	2	82	0	100
(2) 0.5% Rotenone (*D. elliptica*)	5	89	1	91	0	100
Check	46	—	11		22	
Second Experiment—Golden Acre—just beginning to head.						
(1) Trace Rotenone (*D. malaccensis*)	0	100	5	75	1	92
(4) 0.4% Rotenone (*Cube*)	0	100	2	90	3	79
(5) 0.4% Rotenone (*Cube*)+2% *Lethane*	0	100	6	70	8	53
Check	16	—	20	—	14	—

Since these experiments were conducted on commercial plantings of beans it was necessary to dust when the grower felt they should be dusted, therefore, the population was comparatively low. It might be considered that the control is too high to accurately evaluate the materials, but it is demonstrated that the *Derris malaccensis* dust with only a trace of rotenone gives as high a degree of control as the other dusts.

Cabbage Worms.—Flat Dutch cabbage which were almost ready for market were used in the first experiment and Golden Acre cabbage which were just beginning to head were used in the second experiment. All dusts were applied with an American Beauty bellows-type duster by the same person using a uniform method of dusting. Since the migration factor of the three species of cabbage worms is nil one row plots of 25 plants each were duplicated. Larval counts were made 96 hours after dusting in each experi-

In this test *Derris malaccensis* dust proved as effective as dusts containing rotenone obtained from *D. elliptica* and *Lonchocarpus* sp. in controlling the imported cabbage worm and the diamond back caterpillar, but was somewhat inferior against the cabbage looper.

Potato Aphid.—A field of Rutgers tomatoes was moderately infested with the potato aphid wherein this experiment was conducted. The plants were set 4 feet apart in the row and the rows were 5 feet wide, and plants were "checked" so that

the field could be cultivated in two directions. The plots consisted of 6 rows 10 plants long or a total of 60 plants and each material was replicated twice. The dusts were applied with an American Beauty bellows-type duster with the outlet tube so adjusted that the dust was directed to the undersides of the leaves. One person did all of the dusting in a uniform manner so that the dusts were applied at the rate of approximately 30 pounds per acre. Aphid counts were made 3 days and one week after treatment. For the first count 10 compound leaves were collected at random from the center rows of each plot, placed in paper bags, taken to the laboratory and the live aphids counted. Records for the 3 day count were complicated as many of the dead aphids still clung to the leaves due to the lack of precipitation. For the second count, one week after treatment, all dead aphids had dropped from the plants, therefore, the 10 compound leaf sample from each plot was placed in paper bags and calcium cyanide was added to kill the aphids. The samples were then taken to the laboratory and the total aphids per sample counted. The data from this experiment are set forth in table 3.

Table 3.—An experiment with the potato aphid. Averages of duplicate samples showing the number of live aphids and reduction in population 3 and 7 days after dust applications.

Dusts	3 Day Counts		7 Day Counts	
	No. Aphids 20 Leaves	Per Cent Reduction	No. Aphids 20 Leaves	Per Cent Reduction
(1) Trace Rotenone (*D. malaccensis*)	399	73.2	379	85.2
(2) 0.5 per cent Rotenone (*D. elliptica*)	474	68.2	454	82.6
(4) 0.4 per cent Rotenone (Cube)	637	53.8	482	81.4
(5) 0.4 per cent Rotenone (Cube)+2 per cent *Lethane*	664	55.4	728	72.4
Check	1489	—	2631	—

The records from each replicate were so closely parallel that they were combined for simplicity of the table. The *Derris malaccensis* dust proved slightly more effective than the 0.5 per cent rotenone (*D. elliptica*) dust on the potato aphid. As a further measurement of the effectiveness of these materials, observations were made in the plots from time to time during the season and it was observed that the plants in the check plots and some of the less effective treatments were badly stunted throughout the tomtato season. The 0.4 per cent rotenone+2 per cent *Lethane* dust plot was included here for a further comparison. It was noted that the Lethane as well as other thiocyanate materials tested showed a distinct yellowing of the foliage for a period of approximately 3 weeks, after which the injury disappeared.

EUROPEAN CORN BORER.—An experiment with the second generation of the European corn borer was conducted using nine different dust materials among which were the three dusts listed below. Lincoln hybrid sweet corn, drilled and thinned to a single plant which later had all suckers or tillers removed was used in the experiment. A randomized latin square plot arrangement with plots 4 rows wide and 40 feet long, replicated 4 times was employed. Five applications of the insecticides were applied on a 5-day schedule beginning August 7, with the fourth application delayed for one day so that the grower could complete irrigation of the field. This field was irrigated twice during August, the dusting period, as less than one-half inch of rain fell during the month. The dusts were applied with an *American Beauty* bellows duster in a thorough and uniform manner at an average rate of approximately 30 pounds per acre per application.

When the corn came into silk 25 plants, each showing definite signs of producing an ear, were marked as sample plants in each replicate, thus giving a total of 100 plants for each treatment. When the sweet corn ears were ready to be harvested the sample plants were cut, the ears were carefully examined and the stalks were dissected. The number of borers found in the ears and the stalks were recorded. The detailed records are omitted and only the total borer populations are given in table 4.

The results from this experiment defi-

Table 4.—An experiment with the second generation of the European corn borer. Averages of four replicates showing the number of borers per 100 plants.

Dusts	No. of Borers/ 100 Plants	Per Cent Reduction in Population
(1) Trace Rotenone (*D. malaccensis*)	211	83.5
(5) 0.5 per cent Rotenone (*Cube*)	365	71.6
(6) 4.0 per cent Nicotine (*Black Leaf 155*-Talc-Sulfur)	138	89.2
Check	1274	—

Note: All dusts used in corn borer experiments contained 0.2 per cent "Vatsol OS."

nitely show that the *Derris malaccensis* is superior to the 0.5 per cent rotenone dust made from cube but it is not as effective as the 4 per cent nicotine dust. The plots of 0.5 per cent rotenone (*Cube*) were very poor generally, and although the borer population in the ears was not exceedingly high the borer damage was severe. Many of the borers entered the ears but apparently migrated on to the stalk. This condition was not as noticeable in the *D. malaccensis* and the nicotine plots. The nicotine dust is noted for the borer-free ears in comparison to the total borer population.

SUMMARY.—(1) There appears to be a sizable tonnage of *Derris malaccensis* in storage in this country. This material apparently has little value except for possible agricultural purposes.

(2) The literature reveals very little information on the efficiency of the low rotenone content *Derris malaccensis* root in comparison with other rotenone-bearing plants.

(3) Field tests with dusts made from *Derris malaccensis* root containing only a trace of rotenone were conducted against the Mexican bean beetle, *Epilachna varivestis*, three species of cabbage worms, *Pieris rapae*, *Autographa brassicae* and *Plutella maculipennis*, the potato aphid, *Macrosiphum solanifolii*, and the European corn borer, *Pyrausta nubilalis*. These studies consisted of 6 separate experiments covering 6 species of insects and in every case the *D. malaccensis* dust was equal to or surpassed the 0.5 per cent rotenone or the 0.4 per cent rotenone plus 2 per cent *Lethane* dusts.—12-8-43.

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Relation of Planting Dates of Corn and Japanese Beetle Injury[1,2]

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Japanese beetles injure corn either directly or indirectly in several different ways. The grubs cause a certain amount of injury in the spring and possibly in the fall. In the spring it is not uncommon for corn to be planted in land with high grub populations. In such land considerable injury may occur to early planted corn. The amount of damage will depend on the intensity of grub populations, and is similar to that of white grubs. Frequently there is a considerable grub population in the roots of corn stalks during the fall. In fields where the adult populations were heavy during the summer it is not uncommon to find 4 to 10 grubs feeding at the roots of each plant. Because corn is rapidly maturing at this time it is not believed that such infestation seriously reduces the yield. On occasions the number of grubs that can be removed from around a single plant may reach 75. If this high population of grubs is reached early in August, and the corn is a late-maturing variety, it is conceivable that some fall injury may occur.

The adults injure corn by feeding upon the foliage, cutting the silks and preventing pollination, and opening the tips of the husks so that on occasions moisture may collect and produce conditions favorable to mold. It is not believed that foliage feeding seriously affects yield. The stripping of the silk from the ear and the opening of the tips of the ears so that moisture collects and a moldy condition results, has proved to be quite serious, on occasions, in Maryland.

This paper gives a review of conditions encountered in the field and presents data obtained in experimental plots on corn ear damage as it pertains to moldy corn and the loss of grain from silk destruction.

GENERAL DAMAGE.—Experience indicates that if damage is 10 per cent, or less, it will not be noticed or considered of importance by the average farmer. Many farmers have reported that their losses exceeded 50 per cent of the crop, and surveys following such reports indicated that they were true. These reports were always received after the corn was husked, and, therefore, it was not possible to get a true measure of actual loss due to the fact that unfilled ears and nubbins were left unhusked and in the field. The pictures showing damage to corn give indication of the type of damage frequently encountered and the capabilities of the beetle for damaging corn.

FIG. 1.—Japanese beetle injury to corn on the Harry Miller farm, Level, Maryland in 1941. Many ears were devoid of grain.

The pictures represent conditions as they existed on the farm of Mr. J. Harry Miller, near Level, in Harford County in 1941. Figure 1 shows that many ears were almost completely devoid of grain and therefore no attempt was made to husk them out of the shock. Figure 2 illustrates 100 husked ears, picked at random, as they occurred in the corn pile. For every three good ears, seven were seriously damaged by beetles. While no attempt was made to determine actual grain loss on this farm as a whole, experimental plantings made on May 16, in which 12 different varieties were used, had losses that varied from 21.5 to 40.6 per cent of the crop, depending on variety.

[1] Thanks are due Harry Miller, Leon Ewing, and County Agents Miller and Carroll for the facilities and help furnished.
[2] Eastern Branch Program, 1943.

FIG. 2.—Japanese beetle damage on the Harry Miller farm in 1941. Conditions as they existed in 100 ears picked at random.

EXPERIMENTAL WORK.—During the past six years the Department of Entomology and the Department of Agronomy, at the University of Maryland, have cooperated in experimental work to demonstrate the extent of damage in heavily infested areas, determine varietal resistance, and gather information on the relation of planting dates to beetle damage. Open pollinated varieties, as well as hybrids were used. All of the varieties used are common to Maryland. Some of the hybrids which are of recent introduction have not become established commercially. Early, mid-season, and late varieties were represented.

METHODS.—In all test work the land was prepared in the ordinary manner and fertilizer applied uniformally over the area. The land was marked in both directions and the corn planted with hand planters, and subsequently was thinned to two plants per hill. Each variety was replicated four times and grouped so that all plots had an equal number of exposed hills. The planting sequence was arranged at random in order to reduce possible effect that intensely infested plots might have on adjacent plots. Grain loss is calculated on the percentage of total potential yield of normal ears, of marketable size, as compared with sound ears of marketable size, except incompletely pollenized. Loss is given in terms of grain with 15 per cent moisture. Actual yield is based on the combined weights of normal and sound marketable ears, and ears of marketable size and soundness, but showing incomplete pollination corrected to 15 per cent moisture and adjusted to an acre basis.

RESULTS.—An analysis of the work done shows that the Japanese beetle may do serious damage to field corn, particularly if it silks before August 10. Table 1 gives data collected over a 4-year period, 1938 to 1941, showing damage to corn in test plots that silked before August 10. The data shows that damage may be appreciable. Considering all tests over the period, percentage loss ran as high as 40.6 while loss in bushels reached a total of 23.2 bu. per acre.

Table 1.—Maximum and minimum Japanese beetle damage received in test plots of field corn silking prior to August 10.

Year	No Varieties Tested	Per Cent Ears Damaged		Per Cent Grain Loss		Bushel Loss Per Acre	
		Max.	Min.	Max.	Min.	Max.	Min.
1938	10	77.5	47.4	39.6	14.4	23.2	8.0
1939	12	64.2	21.3	25.0	6.2	13.9	2.5
1940	12	45.3	32.0	6.9	5.5	3.3	1.8
1941	12	82.5	48.0	40.6	21.5	20.7	.0

The abundance of beetles at the silking date is the important factor in the amount

Table 2.—Field data 1938—Comparative damage to corn from Japanese beetles on different planting dates at Blueball, Maryland. Plots 0.05 acre each. Yields calculated in terms of bushels of shelled grain at 15 per cent moisture, and on a basis of a 90 per cent stand for all varieties.

Variety and Planting Dates	Mid-silking Dates	Beetle Damage			Actual Grain Yields Bu. Per A.
		Ears damaged per cent	Grain loss per cent	Grain loss Bu. per A.	
Lancaster Sure Crop					
May 13	July 26	77.5	39.6	21.0	32.1
May 31	Aug. 2	60.4	26.3	12.7	35.5
Hybrid 497 S (Ind.)					
May 13	July 29	67.8	22.1	11.9	41.8
May 31	Aug. 6	56.8	17.3	7.6	36.5
Hybrid G-235 (Funk)					
May 13	July 29	74.0	30.6	18.8	42.5
May 31	Aug. 8	57.8	17.7	9.6	44.6
Hybrid G-244 (Funk)					
May 13	July 29	74.0	29.4	17.7	42.6
May 31	Aug. 10	43.2	9.0	3.5	35.3
Hybrid 845 (Ind.)					
May 13	July 30	75.5	36.1	21.0	37.2
May 31	Aug. 8	52.4	17.5	9.7	45.9
Hybrid 125 (National)					
May 13	Aug. 1	67.1	23.1	14.2	47.2
May 31	Aug. 9	66.2	25.3	14.3	42.1
Golden Queen					
May 13	July 30	74.9	35.4	19.3	35.2
May 31	Aug. 9	54.1	18.0	8.9	40.6
Reid Yellow Dent					
May 13	Aug. 3	78.6	38.0	23.2	37.9
May 31	Aug. 14	21.9	7.5	3.1	38.5[1]
Johnson Co. White					
May 13	Aug. 5	67.2	33.1	22.1	44.7
May 31	Aug. 16	8.9	4.6	1.9	39.3[1]
Eureka					
May 13	Aug. 9	47.4	14.4	8.0	47.4
May 31	Aug. 20	11.6	6.6	2.6	36.8[1]

[1] Corn soft.

of damage done to corn by the Japanese beetle. Late planting has consistently reduced beetle injury. A survey of data over a six-year period indicates that when it is possible to plant corn so that it silks after the peak of the beetle infestation has passed, damage will be negligible. However, it was found that the marginal period for planting to avoid both beetle and frost injury is narrow, and that there is no certain planting date which will guarantee freedom from both types of injury.

Tables 2 and 3 give results obtained in 1938 and 1941 and are typical of differences in damage between early and late plantings. In 1938 the planting dates were May 13 and May 31. The amount of damage varied in varieties, but for the early planted corn the minimum grain loss was 14.4 per cent and the maximum 39.6 per cent while for the late planted corn the minimum loss was 4.6 per cent and the maximum 26.3 per cent. However, it should be noted that maximum loss in any variety silking after August 10 was 9.0 per cent. The 1941 planting dates were May 16 and June 10. Grain loss in the early planted corn varied from 21.5 per cent to 40.6 per cent while that in the late planted corn varied from 0 per cent to 5.8

Table 3.—Field data 1941—Comparative damage to corn from Japanese beetles on different planting dates at Level, Maryland. Plots 0.04 acre each. Yields calculated in terms of bushels of shelled grain at 15 per cent moisture, and on a basis of a 90 per cent stand for all varieties.

Variety and Planting Dates	Mid-silking Dates	Beetle Damage			Actual Grain Yields Bu. Per A.
		Ears Damaged Per Cent	Grain Loss Per Cent	Grain Loss Bu. Per A.	
Lancaster Sure Crop					
May 16	July 24	67.8	29.1	11.3	27.6
June 10	Aug. 6	7.0	1.6	0.6	35.6
New Jersey hybrid 2					
May 16	July 25	74.3	40.6	20.7	30.3
June 10	Aug. 6	12.2	5.8	3.7	59.5
Iowa hybrid 939					
May 16	July 24	69.0	28.3	12.3	31.1
June 10	Aug. 5	3.7	1.1	0.7	59.4
Pioneer hybrid 314					
May 16	July 27	82.5	34.7	18.7	35.2
June 10	Aug. 7	1.1	0.6	0.4	57.5
U. S. hybrid 65					
May 16	July 27	48.0	24.6	13.0	39.7
June 10	Aug. 8	0.0	0.0	0.0	50.6
U. S. hybrid 44					
May 16	July 28	61.4	30.0	17.2	40.2
June 10	Aug. 10	0.0	0.0	0.0	54.1
Golden Queen					
May 16	July 28	50.0	21.7	13.1	47.2
June 10	Aug. 10	3.8	0.6	0.4	64.2
U. S. hybrid 13					
May 16	July 28	65.9	23.4	13.5	44.3
June 10	Aug. 11	6.0	3.9	2.5	61.9
Funk hybrid G-88					
May 16	Aug. 2	62.7	28.5	18.3	45.8
June 10	Aug. 15	1.3	0.8	0.4	50.8
Funk hybrid G-135					
May 16	Aug. 1	59.2	21.5	12.9	47.1
June 10	Aug. 13	2.0	1.2	0.8	68.0
U. S. hybrid 115					
May 16	Aug. 1	52.2	24.8	12.7	38.4
June 10	Aug. 13	2.3	1.0	0.6	60.7
Reid Yellow Dent					
May 16	Aug. 1	68.2	32.1	18.4	38.9
June 10	Aug. 13	3.6	1.6	1.0	58.7

per cent. The differences between early and late planted corn as encountered in plot work in 1941 are illustrated by pictures. Figure 3 reviews conditions for all twelve varieties, while figure 4 shows a breakdown of conditions existing in the variety Lancaster Sure Crop.

Experience indicates that under average conditions peak beetle infestations in Maryland are over by August 10. Therefore, corn planted so that it silked after that date has been found to miss major damage, except in 1939 when beetles remained abundant and active very late in the season. Damage that year amounted to a grain loss of 9.8 per cent on the very latest maturing variety which was in silk on August 18. Varieties silking prior to August 10, 1939 were damaged more than those silking later. The following sug-

gested planting dates for northern Maryland usually allow corn to silk after August 10 and still have time enough to mature before frost:

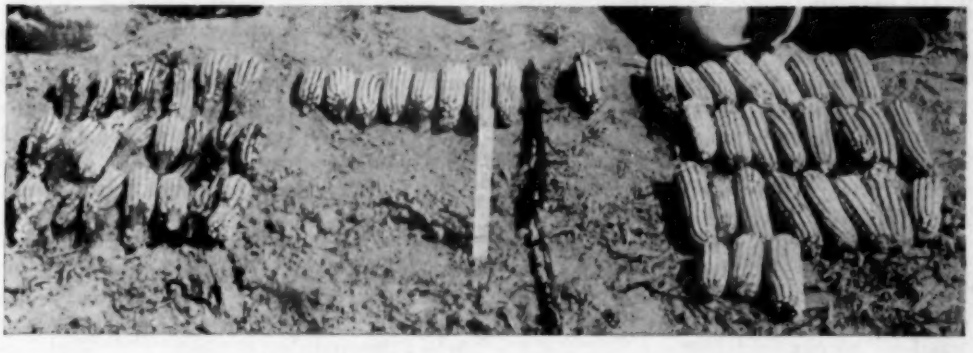
Long season corn	May 25 to June 1
Medium season corn	June 1 to June 7
Short season corn	June 7 to June 14

Available data indicate a relation between beetle feeding and moldy corn. No observations have been made that show the beetle to be a carrier of organisms involved, but this is a distinct possibility. Records from experimental plots indicate, that in years favorable to mold development, the per cent of infected corn ears is greatest in fields that have had the tips of the ears opened by feeding from the beetles. Corn that silked after the peak beetle infestation developed fewer moldy ears than that which silked early and was exposed to beetle feeding. In 1939, ten varieties which silked prior to August 10 averaged 9.4 per cent moldy ears. Another ten varieties planted adjacent, but silking later averaged only 2.2 per cent moldy ears. The variety Golden Queen suffered the greatest damage. The planting which silked July 27 averaged 25.6 per cent moldy ears, while the planting which silked August 11 averaged 7.7 per cent. Similar conditions were encountered in 1940. An analysis of a plot containing 12 different varieties showed that varieties silking after August 10 averaged 44 per cent fewer moldy ears than varieties silking prior to that date.

A B C D

FIG. 3.—Comparative Japanese beetle damage between early and late planted corn.
Left—Planted June 10. A. Good corn—B. Beetle damaged corn.
Right—Planted May 16. C. Good corn.—D. Beetle damaged corn.

Varietal resistance has not been proved. Beetles show a decided preference for some varieties or hybrids. In a series of plantings, beetles will congregate on the preferred varieties, but in the absence of preferred varieties and other preferred food serious damage may result to a variety showing resistance when planted in a mixed series.—1-7-44.



A B C D

FIG. 4.—Comparative damage to Lancaster Sure Crop.
Left—Planted May 16. A. Damaged corn.—B. Good corn.
Right—Planted June 10. C. Damaged corn. D. Good corn.

Pea Aphid Work in Maryland During 1943[1,2]

L. P. Ditman, E. N. Cory, and Howard B. Owens[3]

The 5-year program on pea aphid control in Maryland begun in 1938 was completed with the 1942 season; the results were summarized and published in Station Bulletin #A24 in the spring of 1943. Work was continued in the 1943 season in the same manner and under the same project. Since the conclusion of the 1943 season the project has been terminated and a new one devoted entirely to the timing of aphid treatments will be initiated during the coming year. The results secured in 1943 including some preliminary tests with concentrated sprays are reported in this paper.

The spring of 1943 was generally favorable for pea production; although seeding was somewhat delayed there was ample rainfall and an absence of extremely hot days during the pea growing season. There were winged migrants on peas April 28 at Ridgley. Heavy infestation was observed on alfalfa at College Park on May 1. On peas the aphid population reached its peak at Ridgley May 25 to 27, at which time the fungus attacking the aphid became effective in reducing the population. Injury to peas on the Eastern Shore was perhaps a little greater than normally expected, while severe losses, much greater than normal expectancy, occurred in western Maryland pea growing areas.

The experimental plots were planted late and fungus attacked the aphids reducing the population before the peas were injured, although near-by earlier peas suffered 65–85 per cent losses.

Methods and Results.—The 84 plots of peas available at the Ridgley Substation were divided into two groups of 40 plots, one of which was used for the regular pea aphid treatments and the other for concentrated spray experiments; the remaining four plots were used for borders and received no treatment. Seventeen treatments were applied, each treatment replicated four times in random block arrangement.

The various treatments applied and the results secured are given in tables 1 and 2. All dusting was done early in the morning while dew was still on the plants except one treatment of 0.5 per cent rotenone (derris) dust with 2 per cent nicotine added, which was applied at midday. Concentrated sprays were supplied during the late morning and early afternoon. All treatments were applied under a 25 foot muslin apron. The dusting was done at 3 m.p.h.; spraying at 4.5. Wind velocity varied from 1 to 5 m.p.h. during the period of morning treatments; in the afternoon a strong north-east wind blew up before spraying was completed.

Dusts were applied with a *Model M Messenger* duster. One-half pound of test material was put in the hopper and the amount calculated for one plot was added. After a trial run or two of the machine it was found that amounts of dust applied could be controlled much more accurately and with much less trouble in this manner than by back weighing of dust.

Concentrated sprays were applied with a small 3-gallon per minute power sprayer with small aperture nozzles. The nozzles were arranged at 24-inch intervals in two rows about 12 inches apart, and the nozzles of the two rows were directly opposite. The forward row of nozzles was directed downward, backward, and to the left; those of the back row were directed downward, forward, and to the right. The spray boom was enclosed under a hood 3 feet wide and 8 inches deep; a 25 foot apron was attached.

Results and Discussion.—Table 1 shows that the regular spray of 3 pounds of ground derris with a wetting agent considerably outperformed the other treatments. The 1.0 per cent rotenone (derris), even though it had been stored a year, gave a slightly better kill of aphids than any of the reduced rotenone dusts even though some of them contained 2 per cent nicotine. In concentrated spray tests (Table 2) *Tubicide* compared favorably with the 1.0 per cent rotenone (derris) dust. Nicotine sulfate and pyrethrum sprays did not perform so well as *Tubicide*. The speed of the machine was probably too great and the apron too short to give satisfactory results with nicotine.

[1] Scientific Paper No. A74, Contribution No. 1928 of the Maryland Agricultural Experiment Station, Department of Entomology.

[2] Eastern Branch Program, 1943.

[3] Mr. Geo. J. Burkhardt of the Department of Agricultural Engineering assisted in designing and constructing concentrated spray machinery and in making spray applications.

Table 1.—Results of tests in 1943. Application May 21, 1943.

TREATMENT	AMOUNT PER A	APHIDS PER SWEEP		PER CENT REDUCTION	YIELD SHELLED PEAS PER ACRE
		May 20	May 27		
Spray: 3 lb. 4% rotenone derris plus 4 oz. sodium lauryl sulfate to 100 gal. water.	150 gal.	172	10	94	1476 lbs.
Control		183	287		1269
Dust: 5% rotenone derris, 2% nicotine[1] 20% sulfur.	38 lb.	155	75	51	1492
Dust: 5% rotenone cube, 2% nicotine,[1] 20% sulfur.	40 lb.	173	80	54	1454
Dust: .375% rotenone derris, 2% nicotine,[1] 20% sulfur.	38 lb.	175	78	55	1360
Dust: 5% rotenone derris, 20% sulfur.	42 lb.	164	101	38	1380
Dust: 1% rotenone derris, 1% sodium lauryl sulfate (1 yr. old)	38 lb.	154	57	63	1482
Control		175	271		1367
Dust: 1% rotenone derris plus 1% sodium lauryl sulfate micronized.	32 lb.	174	92	47	1398
Dust: 5% rotenone derris, 2% nicotine[1] 20% sulfur, midday application.	38 lb.	161	87	46	1383

[1] Nicotine from 10% nicotine dust (*Black Leaf 10*).

Table 2.—Results of tests with concentrated sprays. Application May 21, 1943.

TREATMENT	AMOUNT PER A	APHIDS PER SWEEP		PER CENT REDUCTION	YIELD SHELLED PEAS PER ACRE
		May 20	May 27		
Dust: 1% rotenone derris, 1% sodium lauryl sulfate, talc diluent.	38 lb.	141	39	81	1705 lbs.
Nicotine sulfate 4.5 pt. plus 8 oz. soap in 15 gallons of water.	15 gal.	138	50	64	1584
Nicotine sulfate 2.25 pt. plus 4 oz. soap in 15 gallons of water.	15 gal.	132	100	24	1566
Special Red Arrow 3 pt. in 15 gal. water.	15 gal.	150	69	53	1633
Special Red Arrow 1.5 pt. in 15 gal. water.	15 gal.	142	70	51	1623
Tubicide 3 pt. plus 1 pt. *Synol* in 15 gal. water.	15 gal.	138	29	79	1712
Tubicide 1.5 pt. plus 0.5 pt. *Synol* in 15 gal. water.	15 gal.	145	38	74	1591
Special *Red Arrow* 0.75 pt. plus nicotine sulfate 0.75 pt. in 15 gal. water.	15 gal.	140	66	53	1567
Tubicide 0.75 pt. plus *Synol* 0.75 pt. plus nicotine sulfate 0.75 pt. in 15 gal. water.	15 gal.	133	57	57	1544
No treatment.		117	204		1631

Table 3.—Acreage of peas grown and treated in Maryland during 1942 and 1943.

Region	Total Acres			
	Planted	Dusted	Sprayed	Treated
		1942		
Eastern Shore	4,480	1,695	300	1,995
Baltimore City	3,501			
W. Maryland	6,287	890	565	1,455
Totals	14,268	2,585	865	3,450
		1943		
Eastern Shore	4,545	662	405	1,067
Baltimore City	3,951			
W. Maryland	7,272	1,164	560	1,724
Totals	15,768	1,826	965	2,791

Table 4.—Amounts of insecticides purchased and reported used for pea aphid in Maryland in 1942 and 1943.

Region	Dust		Spray	
	Purchased	Used	Purchased	Used
			1942	
Eastern Shore	44,700 lbs.	44,200 lbs.	1,500 lb. 3.5% root	1,500 lbs.
W. Maryland	46,400 lbs.	45,150 lbs.	200 lbs. 3.5% root	200 lbs.
			175 gal. Extract	135 gal.
Totals	91,100 lbs.	89,350 lbs.	1,700 lb. 3.5% root	1,700 lbs.
			175 gal. Extract	135 gal.
			1943	
Eastern Shore	26,000 lbs.	24,300 lbs.	1,500 lb. 3.5% root	1,050 lbs.
W. Maryland	55,360 lbs.	50,185 lbs.	810 lb. 3.5% root	810 lbs.
			100 gal. Extract	60 gal.
Totals	81,360 lbs.	74,485 lbs.	2,310 lb. 3.5% root	1,860 lbs.
			100 gal. Extract	104 gal.

Table 5.—Canners' estimates of results for 1942 and 1943.

Region	Total No. Canners	Number		Control		
		Dusting	Spraying	Good	Fair	Poor
			1942			
Eastern Shore	9	6		2	2	2
Eastern Shore			1	1		
W. Maryland	17	4		2		2
W. Maryland			2	1	1	
Totals	26	10	3	6	3	4
			1943			
Eastern Shore	9	4		2	2	
Eastern Shore			2	1	1	
W. Maryland	17	6		5	1	
W. Maryland			3	3		
Totals	26	10	5	11	4	

Commercial Aphid Control.—Following the 1943 pea season in Maryland an attempt was made to determine the extent of pea aphid treatments in the state. All canners known to be growing peas in Maryland were visited and questioned. The total acreage of peas grown and acreage treated are given in table 3 for 1942 and 1943. Three geographical groups are reported: Eastern Shore canneries, western Maryland canneries, and canneries with plants in Baltimore City, the last group with acreages mostly in western Maryland. The amounts of insec-

ticide reported purchased and the amounts used for pea aphid control are given in table 4.

On the basis of the amount of dust used and total acreage reported dusted, an average of 34.5 pounds of dust per acre was applied in 1942 and 40.7 in 1943. The degree of control obtained by the various canners is given in table 5. The seasons 1942 and 1943 were both favorable for pea aphid control with derris dusts and sprays, as evidenced by the considerable number reporting satisfactory results. Failure in cases familiar to the authors are attributed to ineffective materials or inefficient methods of application, *i.e.* in dusting too rapidly or in too windy weather; poor results from spraying are attributed mainly to improper nozzle arrangement. —2-28-44.

Seasonal Changes in Reaction of Coniferous Evergreens to Methyl Bromide Fumigations

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Many thousands of balled and burlapped nursery plants have been fumigated with methyl bromide to meet requirements for certification under the Japanese beetle quarantine following the authorization of this method of treatment in 1939. Early in the commercial use of fumigation, certain ornamental coniferous evergreens appeared to be much more susceptible to injury by fumigation at the approved dosage schedules than were most of the broadleafed evergreens or deciduous woody shrubs. Reports by nurserymen of foliage injury on conifers have been numerous. Subsequent observations in a number of instances were confusing in that no consistency was evident in the occurrence of injury. Parts of a shipment of common origin and handling showed severe foliage injury on some plants and none on others; again, one shipment would show no injury, yet in the next there would be severe injury, even though the conditions of treatment apparently were uniform.

The approved methyl bromide fumigation is not based on a single dosage-exposure rate, but rather on a series of schedules which show regular changes in the dosage or exposure or both, for designated differences in temperature. In all the following tests the fumigation schedules called for by the existing soil and air temperatures were used. If the soil and air temperatures were different the soil balls were warmed to the air-temperature level before fumigation. It had been determined previously that these compensations for temperature changes were not the cause of injury to coniferous evergreens.

Preliminary studies on this problem were made in February 1941, at Norfolk, Va. In these tests an attempt was made to determine the effects of variations in air circulation, amount of load, post-fumigation aeration, chemical or mechanical protection of foliage, plant size, and the use of alternative schedules (higher dosage and shorter duration than those authorized).

More comprehensive tests were made in March and April wherein several varieties of coniferous evergreens that had shown foliage injury in commercial fumigations were treated at four different dates about 2 weeks apart. These dates were selected as representing the range of the usual period of nursery-stock movement in the spring. The tests were repeated at three locations in Virginia, Maryland, and Delaware. At this time factors that might cause or prevent foliage injury were studied, such as date of treatment, effect of alternative schedules, effect of preheating, and effect of foliage covers.

In 1941–42 a further series of tests were made at the Beltsville Research Center, Beltsville, Md., in which plants were fumigated at various dates between August 29 and May 15 in order to study further the effect of the date (or season) of treating.

VIRGINIA-MARYLAND-DELAWARE TESTS. —All fumigations were made in a pair of identical metal-lined fumigation vaults of

[1] W. L. Caskey and Harold E. Battersby of the Division of Japanese Beetle Control, Bureau of Entomology and Plant Quarantine, assisted in the Virginia-Maryland-Delaware fumigations. Acknowledgement of other assistance is made to E. Howard Phillips and V. A. Johnson of the above Division, and to H. C. Donohoe of the Division of Control Investigations.

Table 1.—Average percentage of foliage injury on coniferous evergreens fumigated with methyl bromide at various dates during the spring of 1941.[1]

Variety	Feb. 19–21		Mar. 12–18		Mar. 26 to Apr. 1		Apr. 11–19		Apr. 24 to May 1	
	Number Fumigated	Per Cent Foliage Injury	Number Fumigated	Per Cent Foliage Injury	Number Fumigated	Per Cent Foliage Injury	Number Fumigated	Per Cent Foliage Injury	Number Fumigated	Per Cent Foliage Injury
Goldplume Sawara false cypress	94	0	27	0	18	15.7	18	96.7	12	87.9
Japanese yew			27	2	27	5.6	27	73.1	17	8.2
Oriental arborvitae			27	5.1	27	3.3	27	17.9	18	6.7
Eastern arborvitae			18	7.5	17	11.4	18	36.1	12	32.3
Peabody arborvitae					5	11.6	9	52.2	9	51.1
Irish juniper	94	0	27	0	27	2.9	27	25.0	18	16.9
Colorado spruce			18	55.5	18	55.8	18	58.0	12	69.5

107 cubic feet capacity mounted on a truck. These vaults were insulated and equipped with heaters and circulating fans.

In the preliminary tests in February two conifers were used, Irish juniper (*Juniperus communis hibernica*) and Goldplume Sawara false cypress (a horticultural form of *Chamaecyparis pisifera*, commonly known as *plumosa aurea*). The tests were made within a 3-day period at one location.

The March-April tests were made at three locations and on four dates at each location. The same varieties and sizes of plants were used as far as possible. Four varieties were used at all locations, namely Goldplume Sawara false cypress, Japanese yew (*Taxus cuspidata*), oriental arborvitae (*Thuja orientalis*), and Irish juniper, with one exception where Peabody arborvitae (*T. occidentalis* variety George Peabody) was substituted for Goldplume Sawara false cypress on the second, third, and fourth dates at one location. Eastern arborvitae (*T. occidentalis*) and Colorado spruce (*Picea pungens*) were used on all dates at two of the three locations.

In all the above tests, regardless of the original purpose of any test, the date of treatment was shown to be of predominant importance. None of the tests made in February showed any foliage injury on the plants. In the March-April tests there was only slight or no injury to plants fumigated in mid-March, slight to moderate injury to plants fumigated in late-March, and general severe injury in mid-April and late-April lots.

Goldplume Sawara false cypress showed this seasonal effect most strikingly with injury ranging from none in February and mid-March fumigations to almost total injury in April. Other varieties showed the same trend to a lesser extent according to their order in table 1, except Colorado spruce, which showed consistent injury at all times. In two of the varieties, Japanese yew and oriental arborvitae, the amount of injury markedly decreased in the late-April as compared with the mid-April treatment.

Beltsville Research Center Tests.—In these tests Japanese yew and Goldplume Sawara false cypress, which had shown the greatest foliage injury in April tests, were used. Lots of each variety were fumigated at various dates between August 1941 and May 1942. The authorized Japanese beetle fumigation schedules for the existing soil-temperature levels were used. During the period from December to early March the plant foliage was uninjured, but light injury showed on the yew and severe injury on false cypress in both fall and spring. The percentages are given in table 2.

Table 2.—Average percentage of injury to Japanese yew and Goldplume Sawara false cypress fumigated with methyl bromide at various dates between August 1941 and May 1942.

Date Fumigated	Per Cent Injury to Japanese Yew	Per Cent Injury to False Cypress
Aug. 29, 1941	10.3	81.6
Sept. 12	3.6	91.6
26	8	75
Oct. 13	10	61.6
Nov. 3	6.6	26.6
17	1.6	16.6
Dec. 17	0	1.6
Jan. 28, 1942	0.6	0
Mar. 12	0	0
26	0	9.3
Apr. 9	0.3	100
27	1.6	95
May 15	7	30

Discussion.—These tests indicate that

a period of high tolerance exists in midwinter in most of the varieties of conifers tested, which is preceded and followed by periods of lowered tolerance. The period of high tolerance apparently coincides with the period of least activity of the plants. While the period of least activity of nursery plants cannot be delimited except in a relative way, it is generally considered to extend from the time of heavy, killing frosts in the fall to a time in the spring when the first swelling of buds or other evidence of new growth occurs. In the tests reported here foliage injury ceased to occur after a series of heavy frosts and began to show again just prior to the first visible symptoms of growth in the spring.

The fall and spring periods of nursery stock movement generally occur at the two ends of this period of least activity, and would therefore coincide with the periods of lowered tolerance as shown by the experimental tests made. Thus the confusing reports of injury to commercial lots of nursery stock can be explained logically by the fact that the fumigations were performed at times when the plants were in varying stages of dormancy, resulting in "spotty" injury. The consistent injury to Colorado spruce in spring tests is attributed to the fact that this species breaks dormancy earlier than the other varieties tested.

A similar change in tolerance to fumigation in relation to the dormancy or nondormancy of the plants is believed to apply to other coniferous evergreens also. It is therefore concluded that fumigation of coniferous evergreens in agreement with Japanese beetle quarantine schedules is inadvisable except where open weather conditions permit their treatment during the period of least activity, or where specific varieties have been tested sufficiently to establish their reaction to fumigation at various seasons of the year.

SUMMARY.—Experimental tests made with seven varieties of coniferous evergreen nursery plants in Virginia, Maryland, and Delaware, to test their tolerance to methyl bromide fumigation schedules as employed against Japanese beetle larvae, showed a definite relationship in six of the seven varieties between the extent of injury to the plants and the season of year at which they were fumigated.

Plants fumigated during late winter when they apparently were least active showed no injury to foliage, even when variations in the technique might have induced it. On the other hand, severe injury resulted when plants were fumigated during late March and April at the time they were breaking dormancy.

While the amount of foliage injury in spring fumigation tests was different for each variety, the same trend from no injury to severe injury was apparent in six varieties. A seventh variety, Colorado spruce, showed severe injury in all tests, but in this species the period of dormancy probably ended in advance of the beginning of the series of tests.

Japanese yew and Goldplume Sawara false cypress were selected for fumigation experiments between August 1941 and May 1942 at Beltsville, Md. In this series a tolerant period was evident between December and February, preceded and followed by periods during which foliage injury occurred.

The period during which no foliage injury occurred coincided with the least activity of the plants. Since the period of lowered tolerance in both fall and spring tests occurred at the time of normal nursery stock movement, it is believed that the injury to commercial nursery stock from fumigation was due to the plants being relatively active. It was concluded that fumigation of coniferous evergreens in accordance with Japanese beetle quarantine schedules is inadvisable except where open weather conditions permit their treatment during the period of least activity or where specific varieties have been tested sufficiently to establish their reaction to fumigation at various seasons of the year.—12-29-43

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Tomato Pinworm Control in the Greenhouse[1]

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The tomato pinworm, *Keiferia lycopersicella* (Busck), has been a pest of greenhouse tomatoes at the Virginia Truck Experiment Station for the past 10 years. This pest has necessitated rigorous clean-up measures in and about the greenhouse and fumigation and steam sterilization within the greenhouse, and finally hand picking before an early spring tomato crop could be grown.

In view of this trouble, pinworm control studies were started in January 1943. Since Morrill (1926), Thomas (1936) and Elmore (1937) report varying degrees of control with arsenicals, and Lee A. Strong reported that Bureau Entomologists in California were finding cryolite to be quite effective, these materials were used in the first test. Wilcox & Elmore (1943) and Elmore & Holland (1943) reported on pinworm control with cryolite in California.

SPRAY TESTS.—For the first spray test on tomatoes and the first two applications of the first test on eggplants the materials were atomized to the plants with a small paint spray-gun with an air pressure of 15 pounds. In all other spray tests, the materials were applied in the form of a coarse spray with a knapsack sprayer that maintained a pressure of about 125 pounds. In all instances both upper and lower surfaces of the leaves were thoroughly sprayed.

In the first test on tomatoes five potted plants were used for each treatment. The first treatments were made on January 8, when the plants were 6 to 8 inches in height. When the fourth and final application was made the plants were 3 to 4 feet tall and a quart of material was used to treat the five plants. Control records were made by counting the number of pinworm tunnels that appeared on the different plants. In practically all subsequent spray tests the tunnels were examined in detail and records were taken on the condition of the larvae within the tunnels.

The materials used, the time of application and the results obtained are given in table 1. It is apparent that in this first test there was no significant difference between the cryolite and the calcium arsenate treatments but that both materials resulted in a significant reduction in the number of tunnels. However, the 56 to 71 per cent reduction would not be considered as very good control. The addition of soybean flour did not increase the effectiveness of cryolite significantly.

While these first pinworm experiments were being made, the tolerance of tomato and eggplant seedlings to insecticide dips was being studied in other tests. In eight different dipping tests a total of 85 different treatments were compared and in one of these tests it was observed that eggplants dipped in 0.5 per cent *NNOP*[2] and 0.5 per cent *NNOR*[3] mixtures had zero and two pinworms respectively on eighteen plants, while a similar number of check plants had eighteen pinworms on them. In these dipping tests the entire plant was dipped for approximately fifteen seconds. In view of this good pinworm control on plants dipped in *NNPO* and *NNOR* further tests were made with these materials.

Table 1.—Results of the first spray test on tomatoes for the control of tomato pinworms. Treatments were made January 8, 15, 22 and 29. Pinworm tunnels were counted on five plants for each treatment on January 18 and February 8.

MATERIALS	AVERAGE NUMBER OF TUNNELS PER PLANT		PER CENT CONTROL
	Jan. 18	Feb. 8	FEB. 8
Cryolite (2-50)	0.8	13.0	68
Cryolite-soybean flour (2-1-50)	1.2	11.6	71
Calcium arsenate (2-50)	1.8	17.6	56
Check	4.2	40.0	—
Difference required for significance at odds of 19 to 1	1.5	10.0	—

In the second spray test on tomatoes, 5 replications of six plants each were used for each treatment. The first application was made February 15 when the plants were about a foot tall. The materials and the strengths at which they were used, the time of treatment and the results obtained are given in table 2. As shown by the data in this table, 2 applications of *NNOP* gave 100 per cent control while 2 applications

[1] Eastern Branch Program, 1943.

[2] *NNOP* contains 92.45% technical mannitan monolaurate, 2.00% pyrethrins and 5.55% pyrethrum extractives.

[3] *NNOR* contains 97.1% technical mannitan monolaurate, 1.0% rotenone and 1.9% other derris extractives.

of cryolite resulted in only 21 per cent control.

In the third spray test on tomatoes, *NNOP* (1 to 200), and *NNOR* (1 to 200) were each applied to 25 plants. Three days after treatment the *NNOP* and *NNOR* treated plants had 6 and 21 living larvae respectively, indicating that the *NNOP* gave better control than the *NNOR*.

In the first test on eggplants, 3 replications of three plants each were treated with each material and a similar number of plants were left as untreated checks. The materials tested were *NNOP* (1 to 400), and *NNOR* (1 to 400). The first application was made on February 26, when the plants were from 6 to 8 inches tall and other applications were made on March 15 and 19.

Records were taken of the number of living larvae on each plant on March 19 just before the third spray application was made on that date. A final larval count was made on March 22, three days after the last spray application.

After the first application was made on February 26, the pinworm population did not increase very rapidly until about the time the second application was made on March 15, when there were 21, 20 and 100 pinworm tunnels respectively on the *NNOP*, *NNOR* and check plants On March 19, three days after the second application, counts revealed that although many larvae had been killed by the two applications, there were still 25 and 33 living larvae on the *NNOP* and *NNOR* treated plants respectively as compared to 246 on the untreated check plants. However, a third application made immediately after the counts on March 19, reduced the population by March 22, to 1 and 2 living larvae respectively on the *NNOP* and *NNOR* treated plants. By this time the pinworm population had increased to such an extent on the check plants that the foliage was practically destroyed and accurate counts could not be made on these plants. Thus, in this test 3 applications of either *NNOP* or *NNOR* at dilutions of 1 to 400 gave practically complete control of the pinworms.

In this experiment it was noted that both the *NNOP* and *NNOR* treatments gave good control of the spinach aphid *Myzus persicae* (Sultz.), and of all stages of the greenhouse whitefly *Trialeurodes vaporariorum* (Westw.). The check plants

Table 2.—Results of the second spray test on tomatoes for the control of tomato pinworms. Treatments were made February 15 and 25. Counts of live and dead larvae were made on 30 plants for each treatment on February 18 and March 2.

	Condition of Larvae			
	February 18[1]		March 2	
Materials	Live	Dead	Live	Dead
NNOP (1 to 200)	10	18	0	3
Cryolite (2–50)	20	7	15	4
Check	43	2	25	0
Difference required for significance at odds of 19 to 1	11	—	11.5	—

[1] In making the counts on this date all larvae and tunnels were removed from the plants.

became so heavily infested with spinach aphids that it was necessary to spray them on March 19 with a mixture of 40 per cent nicotine sulfate 1 to 600 plus soap at 1 to 600. This nicotine-soap spray had little effect on the whitefly and pinworm populations as both of these insects continued to increase on the check plants.

In the second test on eggplants, three replications of three plants each were used for each treatment. The plants were about 20 inches tall and were setting fruit. Applications were made on April 13 and 19, and counts of living and dead larvae were made on April 22. The materials and strength at which they were used and the results obtained are given in table 3. As shown by the results given in this table, the *NNOP* and *Extrax*[1] were equally effective and both gave good pinworm control. While *Red Arrow*[2] and *Evergreen*[3] were considerably less effective. It was noted in this test that all of these materials gave good control of the spinach aphid, and that on *NNOP* and *Extrax* treated foliage a large percentage of the whitefly eggs did not hatch and nearly all of the nymphs that did hatch, died before they became attached to the leaf. Also, practically all of the whitefly nymphs and pupae were killed by these two materials. The plants in this experiment were not

[1] The *Extrax* used in this experiment contained 2.5% rotenone, 7.5% other derris resins, 0.4% pyrethrins, 32.1% petroleum oils, 35.0% polyglycol esters, 2.5% pine wood oil acids, 20.0% glycol dichloride.

[2] The *Red Arrow* contained 10.0% cocoanut oil soap, 7.0% sulphonated cocoanut oil, 3.75% petroleum ether extracts of pyrethrum (including 0.9% pyrethrins), 1.66% rotenone, 0.50% fatty acid esters of glycols sulphated, 0.75% sodium tetradecyl sulphate, 21.0% camphor oil, 7.0% pine oil.

[3] *Evergreen* contains 6% pyrethrum extractives.

treated for one month and by this time the pinworms had become numerous again, however, one application of *NNOP* (1 to 400) gave practically complete control.

Table 3.—Results of the second spraying test on eggplants for the control of tomato pinworms. Treatments were made April 13 and 19. All materials were used at a 1 to 400 dilution.

Materials	Larvae on Nine Leaves April 22		
	Dead	Alive	Per Cent Dead
NNOP	144	4	97.3
Extrax	90	3	96.8
Red Arrow	96	45	68.5
Evergreen	93	66	58.5
Check	1	276	0.4
Difference required for significance at odds of 19 to 1		4.2	—

Dipping Tests.—In order to test the contact insecticidal values of several pyrethrum and rotenone extracts, experiments were made in which pinworm larvae were dipped in the different solutions.

This was done by collecting leaves from infested plants in the greenhouse and taking them into the laboratory. In a few instances the leaves were placed in battery jars and the following day the larvae that had crawled from the leaves were collected and used for the dipping tests. In all other cases the larvae were removed from the tunnels and placed in small shell vials until a sufficient number for one treatment had been collected. In all treated and check lots the larvae were handled with tweezers and in most instances the check larvae were dipped in water. For each replication of each treatment, a drop of the insecticide was placed on the undersurface of a leaf and the larvae were placed in the drop for about 10 seconds, then removed to a dry leaf for about 30 seconds. Then the larvae were placed on fresh leaves in petri dishes. Leaves in the petri dishes were kept fresh by means of moist cotton wrapped around their stems. The larvae were treated individually.

By this dipping method six different experiments were conducted in which from two to five different materials were used in each. In each experiment each material was tested at varying dilutions, no treatment being used at less than three, nor greater than eight different dilutions.

Since the dilutions of 1 to 100, 1 to 200, 1 to 400 and 1 to 12,800 gave results in accordance with the other dilutions and as these dilutions were not used for all of the materials in all of the tests, only the 1 to 800, 1 to 1,600, 1 to 3,200 and 1 to 6,400 dilutions will be discussed in this paper.

In the six dipping experiments *NNOP* and *NNOR* occur together only in the April 4 and 14 tests. Therefore, the results for these two materials in these two tests may be combined. This is done in table 4. From the results as shown in this table it is apparent that the *NNOP* gave a much greater pinworm kill at these dilutions than the *NNOR*.

Table 4.—Results of dipping tomato pinworm larvae in *NNOP* (pyrethrum) and *NNOR* (rotenone) materials.

Dilution	Number Larvae	Per Cent of Larvae Killed[1]	
		NNOP	*NNOR*
1 to 800	20	100	40
1 to 1600	20	95	30
1 to 3200	20	75	20
1 to 6400	10	50	20

[1] In the check none of the 20 larvae dipped in water were killed.

Since the *NNOP* and *NNORP* occur together in the October 1, 29 and November 2 dipping experiments, the results of these tests have been combined and are given in table 5. From the results as shown in this table it may be said that *NNORP* gave some pinworm control but it was not as effective as the *NNOP*. *NNORP* is a specially prepared mannatin monolaurate-rotenone-pyrethrum mixture containing 1 per cent rotenone and 1 per cent pyrethrins.

Table 5.—Results of dipping tomato pinworm larvae in *NNOP* (pyrethrum) and *NNORP* (rotenone-pyrethrum) mixtures.

Dilution	Number Larvae	Per Cent of Larvae Killed[1]	
		NNOP	*NNORP*
1 to 800	30	93	40
1 to 1600	60	73	53
1 to 3200	60	60	40
1 to 6400	60	50	13

[1] In the check 5 per cent of the 60 larvae dipped in water were killed.

The technical mannitan monolaurate, *NNO*, was tested only in the October 29 experiment and was found to give practically no kill of pinworm larvae at dilutions of 1 to 800, 1 to 1600 and 1 to 3200.

NNOP and *Extrax* were compared in the April 10, 14 and November 2 experiments, so the results of these tests have been combined and are given in table 6. As shown by the results in this table the *NNOP* and *Extrax* treatments were about equally effective at all dilutions except possibly the 1 to 6400 strengths where the *NNOP* was slightly better than the *Extrax*.

Table 6.—Results of dipping tomato pinworm larvae in *NNOP* (pyrethrum) and *Extrax* (rotenone-pyrethrum) mixtures.

Dilution	Number Larvae	Per Cent of Larvae Killed[1]	
		NNOP	*Extrax*
1 to 800	15	100	100
1 to 1600	45	89	96
1 to 3200	45	67	70
1 to 6400	30	50	30

[1] In the check 3 of the 45 larvae dipped in water were killed.

In two dipping experiments on April 10 and 14, *Red Arrow* was found to be slightly less effective than *NNOP* and *Extrax* at 1 to 800, 1 to 1600, 1 to 3200 and 1 to 6400 dilutions. While in one experiment on April 14, *Evergreen* was found to be as effective as *NNOP* and *Extrax* at 1 to 800 and 1 to 1600 dilutions but less effective than these other two materials at 1 to 3200.

OVICIDAL TESTS.—The ovicidal value of *NNOP* and *NNOR* was first measured by placing a drop of the insecticide on the egg in its natural position on the leaf. Within four or five seconds the drop was removed by mopping it up with a piece of dry cotton. Check eggs were treated with water. Treatment was made on April 5, and final counts were made on April 14. Both materials resulted in 100 per cent kills of the eggs at dilutions of 1 to 800, 1 to 1600 and 1 to 3200, while dilutions of 1 to 6400 and 1 to 12,800 killed very few of the eggs. All water treated eggs hatched normally.

The ovicidal effect of pyrethrum and rotenone extracts was further tested by spraying eggplant foliage in the greenhouse on April 13. The materials were applied with a knapsack sprayer at 11 A.M. and leaves containing eggs were removed from the plants between 3 and 5 P.M. of the same day. Moist cotton was placed over the stems of the leaves and they were kept in large petri dishes. Four to six leaves were selected from each treatment and the number of eggs varied from three to ten per leaf. The eggs were examined daily for ten days. The materials used and the results obtained are given in table 7.

Table 7.—Ovicidal value of pyrethrum and rotenone sprays on tomato pinworm eggs. All materials were used at 1 to 400 dilutions.

Materials	Number Eggs Treated	Number Eggs Hatched	Per Cent Kill
NNOP	24	0	100
Extrax	25	0	100
Red Arrow	36	0	100
Evergreen	35	30	14
Check	33	32	3

The data in this table show that *NNOP*, *Extrax* and *Red Arrow* at dilutions of 1 to 400 gave a 100 per cent kill of the eggs; while *Evergreen* gave only 14 per cent kill.

In addition to the above mentioned experiments in which pyrethrum dips and sprays have been very effective in controlling the tomato pinworm, it should be mentioned that in April 1943, 1200 tomato seedlings were taken from a greenhouse that was heavily infested with pinworms. Before these plants were set out in a cold frame, 1,000 of them were dipped for 15 seconds in an *NNOP* 1 to 200 mixture, and 200 left untreated. No pinworms appeared on the treated plants while the untreated plants became heavily infested within a few days and it was necessary to make several spray applications of *NNOP* to clean up the infestation.

Also, in September 1943 pinworm infested tomato seedlings were dipped in *NNOP* 1 to 200 before they were set in a commercial greenhouse planting and then thoroughly sprayed with the same material about three weeks later. By the middle of November ripe tomatoes were being picked in this house and practically no pinworms were present, while untreated plants in a greenhouse less than fifty feet away were heavily infested.

In all of the tests where infested foliage was treated, practically all of the dead pinworm larvae observed, were found within their tunnels. The indications were

that the spray material penetrated into the tunnel where the larvae piled up their moist excrement and frass at the point of their entrance into the leaf.

These materials were not tried on tomato pinworms in the field, however, in one small test on potato tuber worms, *Gnorimoschema operculella* (Zell.) mining in potato foliage in the field, *NNOP* killed 19 of 30 larvae, and *NNORP* killed 20 out of 30 larvae.

SUMMARY.—In spray tests on tomatoes in the greenhouse it was found that 4 applications of either calcium arsenate or cryolite, gave a partial but not a practical control of tomato pinworms; while 2 applications of certain pyrethrum and rotenone sprays on tomato and eggplant foliage gave excellent control of this pest, actually killing the larvae within the tunnels.

In dipping tests in which pinworm larvae were submerged in very weak concentrations of several different pyrethrum and rotenone mixtures it was found that pyrethrum (*NNOP*) was more effective than rotenone (*NNOR*). Also, *NNOP* (2 per cent pyrethrins) was more effective than *NNORP* (1 per cent pyrethrins and 1 per cent rotenone). The mannitan monolaurate, *NNO*, base for these mixtures killed very few pinworm larvae.

Extrax was found to be equally as effective as *NNOP*, while several other pyrethrum and pyrethrum-rotenone mixtures were found to be less effective.

In ovicidal tests, pyrethrum and rotenone mixtures gave practically complete control of the pinworm eggs in both dipping and spraying tests.

It was observed in several of the tests that both rotenone and pyrethrum mixtures gave excellent control of the spinach aphid and of all stages of the greenhouse whitefly.

In one small field test pyrethrum and rotenone mixtures killed about 65 per cent of the potato tuber worm larvae mining in potato foliage.—12-7-43.

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D. B. Mackie, of the California State Department of Agriculture, Sacramento, died on the morning of April 30, 1944. Details of the occasion have not yet been received. A more extended notice will be printed in the June number of the *Journal*.

VICTOR I. SAFRO

Major Victor I. Safro, U. S. Army Air Force died May 23, 1944 in the Old Cantonment Hospital, Mitchell Field, Long Island, New York. Death was caused by post-operative pneumonia following a series of operations. A more extended notice will appear in the June number of the *Journal*.

Insecticidal Uses of Tartar Emetic: Against Onion Thrips in New York

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A brief statement by Richardson (1934) to the effect that tartar emetic, in combination with molasses, was very toxic to adult gladiolus thrips, *Taeniothrips simplex* (Morison), eventually aroused the interest of nearly all investigators concerned with the control of thrips of economic importance. Apparently no field trials of the material against thrips were reported until Nelson (1938) used it with brown sugar and found it as satisfactory as paris green in toxicity, and more satisfactory from the standpoints of cost and foliage injury. Bailey (1938) stated that tartar emetic and brown sugar showed promise according to results in the U. S. Department of Agriculture, and the following year Nelson & Weigel (1939) published a complete spray schedule for gladioli using these two at 4 and 16 pounds respectively per 100 gallons of water. Johnson & Smith (1940) found that the spray formula could be reduced to a 2-4-100 concentration using technical grade tartar emetic. The residual effect of sweetened tartar emetic spray was pointed out by Eichmann (1940) who found this insecticide effective against gladiolus thrips on carnations. Further support for recommendations for the use of tartar emetic against this insect have been presented by McCulloch & Weigel (1941), Wilson & Watson (1941), and Smith (1943). The chief concern in the work of the last-named author was that of finding substitutes for both tartar emetic and sugar, the only one found for the tartar emetic being another antimony compound, sodium antimonyl lactophenolate.

The use of tartar emetic in control of the citrus thrips, *Scirtothrips citri* (Moult.), on various citrus fruits has been investigated by workers in California. Boyce & Persing (1939) reported favorable results with tartar emetic and cane sugar at 4-8-100 on lemons despite some injury from the spray on leaves already bearing sulfur deposits. Persing *et al.* (1940) surveyed the entire problem and gave results of field tests leading to recommendations of spray formulas for use on lemons and oranges. They described some fruit injury where thrips scarring was already present. Certain operators complained of some nose and throat irritation and of a slight temporary skin rash on hot days when the perspiration rate was high. Lewis (1940) described the construction of spray-dusters which make possible the more rapid application of tartar emetic sprays on citrus trees. Woglum (1940) gave tartar emetic spray recommendations for central and southern California and Arizona. Wilcomb (1940) segregated other commonly used spray materials into those which were compatible and non-compatible with the tartar emetic. Persing & Boyce (1941) gave results of research on types of sprayers, effects of various weather conditions, volumes and concentrations, compatibility, effects of spray residues on beneficial insects, and spray schedules for lemons, oranges, grapefruit and tangerines. Persing & Beier (1941) recommended 3 to 4 pounds of tartar emetic per acre on lemons and half of these quantities for oranges with amounts of sugar used equal in weight to the tartar emetic. They also indicated the possibility of using potassium antimony citrate in place of the tartar emetic. Munger (1942) gave evidence to show that sugar in the spray attracts citrus thrips as an article of diet, this after an earlier report by Boyce & Persing (1939) suggesting its value to be also attributable in large measure to its hygroscopic action. Persing & Boyce (1942) then called attention to the fact that some sugar is necessary for tartar emetic to be effective, and, while sucrose is the best of the sugars, others such as sorghum syrup or honey may be used.

Among the other interesting observations made by the California group, one which has attracted wide attention concerns the finding of citrus groves in which tartar emetic sprays have in large measure lost their efficiency. This finding of another case of the building up of a "resistant" or "tolerant" race was reported to

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the citrus trade by Persing, Barnhart Worthy, and Boyce (1942) and to the entomological profession by Boyce, *et al.* (1942). As an alternative to the tartar emetic in "resistant" areas Persing, *et al.* (1943) suggested the use of nicotine sulfate-sugar on lemons, and either this spray or a sulfur application on oranges, depending upon the time of year at which protection is needed.

As regards the effect of tartar emetic sprays on beneficial insects, Eckert (1940) pointed out that beekeepers and growers should be advised that the insecticide is toxic to bees in concentrations considerably under those recommended for thrips. He also noted, however, that little injury should result because the sugar solution used is not attractive to bees, the spray is spread thinly over the trees, and the spray is not applied until after the majority of petals have fallen. The same general conclusion was reached by Holloway *et al.* (1942) in their tests on the effect of sprays on *Camperiella bifasciata* (How.), the parasite of yellow scale, *Aonidiella citrina* (Coq.). They found that while tartar emetic was very toxic to the parasites, the sprays did not reduce their numbers in the field because the deposits were not attractive as a source of food.

Against the greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), tartar emetic was found effective in laboratory tests by Persing *et al.* (1941) as was also potassium antimony citrate. Bartlett & Persing (1941) compared tartar emetic with other stomach poisons, including fluorine compounds, and again found this insecticide the most effective.

The use of potassium antimony tartrate has been investigated by a number of other workers concerned with different problems. Gilmore & Milam (1933) found a 5 per cent solution in isoamyl salicylate attractive and very toxic to hornworm moths, *Protoparce spp.* when placed in feeding stations, and later Scott & Milam (1943) stated that feeders filled with liquid containing 10 per cent of sugar combined with 5 per cent of tartar emetic were effective in killing adults. Burdette (1934) reported the toxicity of tartar emetic-syrline spray to adults of the corn earworm, *Heliothis armigera* (Hbn.), but in field tests found the action too slow to prevent oviposition. Poos (1941) was not satisfied with results when using tartar emetic with brown sugar in an effort to control *Frankliniella fusca* (Hinds) causing peanut "pouts." His tentative conclusion was corroborated by the work of Shear & Miller (1941) who failed to secure satisfactory control with 10 applications. They attributed the failure to the fact that the thrips fed in unopened leaflets into which the spray did not penetrate, and apparently the same difficulty was encountered by Lathrop (1942) in an attempt to control the blueberry thrips, *Frankliniella vaccinii* Morgan. On young cotton plants Eyer & Medler (1941) found tartar emetic more satisfactory than sodium antimonyl lactophenolate in controlling *Frankliniella occidentalis* (Perg.) in that its action was more rapid. Counts made one week after application of treatments showed the residual effects to be about the same. Against the grape thrips, *Drepanothrips reuteri* Uzel, Bailey (1942) recommended spraying with tartar emetic-sugar-water (2-4-100) to prevent injury to young shoots and berry clusters. Weigel & Johnson (1940) found tartar emetic effective against the common red spider, *Tetranychus telarius* (L.) on greenhouse cucumbers despite some injury, and likewise obtained control on carnation cuttings although the effective materials, other than glycerine, which were used with the tartar emetic left objectionable residues. Dustan (1943) obtained high kills of the larvae of the greenhouse leaf tier, *Phylctaenia rubigalis* (Guen.) with tartar emetic and brown sugar spray, and found that effectiveness was reduced by the addition of spreaders.

Against the onion thrips, *Thrips tabaci* Lind., Anderson & Walker (1940) found tartar emetic very satisfactory on onions and snap beans in the greenhouse, but results were not as good on onions in the field. In both laboratory and greenhouse tests Eichmann (1940) obtained high kills of onion thrips with a tartar emetic-sugar spray on carnations although at concentrations as low as 2-4-100 some petal injury occurred on light-colored varieties and an objectionable residue was left after too frequent applications. Somewhat later Eichmann (1942) recommended the tartar emetic sugar-water at 1.5-3-100 for onion thrips on greenhouse carnations with the spray applied under humid conditions to prevent flower injury. In field tests on onions Fisher & Manis (1942) ob-

tained satisfactory kills of thrips and considerable increases in yields with 2 pounds of tartar emetic and 1 gallon of sugar beet molasses in 100 gallons of water. From their results they recommended the spray at 100 gallons per acre, two applications 7 days apart with the first one being made when injury first appears, the use of a sprayer capable of developing 350 to 400 pounds pressure, and sufficient nozzles to direct the spray at both the sides and the tops of the plants.

Research on the control of the onion thrips, including both field and greenhouse investigations, has been in progress at Cornell University since 1930. During the summer of 1939 the first test of tartar emetic was conducted, and since that time practically all experiments in the field of chemical control have centered around the use of this material. Greenhouse tests have been conducted in the insectary at Ithaca while field tests have been conducted on onions grown on the mucklands in Orange and Oswego Counties. For convenience, results of the experiments have been grouped according to the various phases of the tartar emetic problem with which the tests were concerned rather than in chronological order or according to means of application of treatments (laboratory sprayers, knapsack sprayer, boom power sprayer, etc.).

Table 1.—Effects on thrips populations and onion yields of application of sprays containing varying amounts of tartar emetic and sugar.

Tartar Emetic, Sugar and Water Concentrations	Applications	Thrips per Plant	Yields Bu/Acre
Experiment 1:			
2- 4-100	2	15.0	493
3- 4-100	2	9.1	489
4- 4-100	2	10.0	515
Check — — —	—	51.5	535
Diff. for sig. odds 19:1	—	18.0	Diff. insig.
Experiment 2:			
1- 4-100	4	4.7	587
2- 4-100	4	3.4	596
4- 4-100	4	1.7	594
6- 4-100	4	2.4	580
Check — — —	—	13.0	570
Diff. for sig. odds 19:1	—	3.9	Diff. insig.
Experiment 3:			
0- 4-100	2	5.0	
2- 4-100	2	1.0	
4- 4-100	2	2.0	none
0-12-100	2	27.0	taken
2-12-100	2	0.0	
4-12-100	2	1.0	
Experiment 4:			
2- 4-100	5	11.9	685
4- 8-100	5	8.2	737
Check — — —	—	76.5	645
Diff. for sig. odds 19:1	—	10.7	80

CONCENTRATIONS.—Four experiments have been conducted in determining the most effective concentrations of tartar emetic and sugar. Results are presented in table 1. In experiment 1 the five treatments, including checks, were replicated 4 times on field plots each of which was 12 rows in width and 25 feet in length. Counts were made of the thrips on 20 plants selected at random in each plot two days after the last application. Sprays were applied with a knapsack sprayer. In Experiment 2 the plot design was a 5×5 latin square with each plot 4 rows wide and 25 feet long. Counts shown in the table were taken on 10 tagged plants in the two center rows of each plot 3 days after the last spray application on July 29. As in Experiment 1, a knapsack sprayer was used to apply the sprays. The data given for Experiment 3 were taken from a table of results obtained in a factorial design experiment conducted in the greenhouse on potted onions. Sprays were applied with a small perfume atomizer attached to an air pump, and thrips counts were made on all plants 3 days after the second application. The power sprayer shown in figure 1 was used in Experiment 4. Applications were made at 5- to 7-day intervals beginning when the onions were about 6 inches high. The three treatments, including checks, were replicated three times on plots 6 rows wide. Discs of 0.038 in aperture were used in the nozzles, pressure was maintained at 150 pounds, and the volume applied was about 100 gallons per acre. Thrips counts were taken on 25 plants in each plot approximately one month after the first application.

The data obtained from the four experiments show that while, in general, some slight increases in kills of thrips may be obtained by using larger quantities of tartar emetic and sugar, results as good from the practical standpoint may be expected with 2 and 4 pounds respectively.

TIMING OF APPLICATIONS.—The field plot design suggested by Glasgow (1940) for determining the timing of applications in a control program was used in Experiment 5 to determine the most effective number of applications of tartar emetic-sugar spray (2-4-100) as well as the most desirable time to begin spraying. Duplicate plots of 52 rows 75 feet long were used for comparing numbers of applications varying from 1 to 9 and starting

dates beginning June 17 and extending through August 14. Thrips counts were not taken after the last two applications, so results shown in table 2, relative to the time of starting applications, are summarized for the first seven starting dates only. They indicate strongly the desirability of beginning applications considerably ahead of the time at which damaging populations of thrips might be expected. In view of the residual effect of the sprays such a find is not surprising.

Table 2.—Timing of tartar emetic sprays: Starting dates.

Date Started	Per Cent Reduction of Thrips	Yield Increases Bu/Acre
June 17	89.8	62.9
25	87.4	65.4
July 1	77.5	49.7
9	77.9	29.7
16	62.7	21.5
22	65.6	26.6
31	32.9	−20.5

In table 3 are summarized the data from the rows on which applications were started on June 17, the segregation in this table being according to the numbers of applications the various rows received. The thrips counts, made on August 4, four days after the seventh application, revealed the desirability of making several applications of the spray and showed further that the early sprays are of importance in building up a residue on the leaves. Also shown in table 3 are the thrips counts from an unreplicated field test, Experiment 6, in which plots 12 rows wide and 750 feet long were given three applications of 2-4-100 spray with the power sprayer and then divided into smaller plots for additional 4 and 5 applications with a knapsack sprayer. The first sprays were applied on July 2nd, the last sprays on July 25, and the counts of thrips on 25 plants in each plot were made on August 2. As in the preceding experiment, there was an increase in kill of thrips with addition of sprays, but the increases were not reflected in terms of yield differences.

Table 4 presents the results of Experiment 7 in which a 5×5 latin square of plots, each 4 rows by 25 feet, was used to determine the best interval between applications of the 2-4-100 spray. Treatments were begun June 27 with a knapsack sprayer, thrips counts were made on 20 plants in each plot on July 11th, and spray operations were continued through August 8. As the data showed sudden increases in thrips kills between the 5- and 7-day intervals and between the 3- and 5-day intervals it would probably not be safe to wait longer than 7 days between applications, and during periods of severe infestations the shorter intervals would likely prove more effective.

Table 3.—Timing of tartar emetic sprays: Number of applications.

Applications	Thrips per Plant
Experiment 5:	
0	146.2
1	119.7
2	154.9
3	142.3
4	150.5
5	98.4
6	29.0
7	6.9
Experiment 6:	
0	69.9
3	32.6
4	17.6
5	13.0

Volume and Pressure.—In comparing different volumes and pressures in the application of tartar emetic sprays, three experiments have been conducted as shown in table 5. In all three the power sprayer was used to make 5–6 applications of spray at approximately 6-day intervals beginning when the onions were 6 inches high. Only one of the experiments contained replicated plots for the purpose of statistical analysis of the data. In all three experiments the total number of thrips on 25 plants in each plot were counted at least 3 weeks after the last treatment. The indication from this work is that the application of greater volume is of at least as great importance as the attainment of high pressure with the sprayer. Such seems to be in contradiction

Table 4.—Timing of tartar emetic sprays: Interval between applications.

Interval	Thrips per Plant	Yields Bu/Acre
3 days	.7	734
5 days	4.5	732
7 days	8.9	715
10 days	8.0	711
Check	38.2	684

Table 5.—Effects on thrips populations of different volumes and different pressures in the application of tartar emetic sprays.

EXPERIMENT NUMBER	POUNDS PRESSURE	DISC SIZE	AVERAGE THRIPS/PLANT	YIELDS BU/ACRE
8	150	0.038 in.	23.4	559
8	150	0.045	11.8	518
8	Checks	—	50.3	523
9	150	0.03	14.2	688
9	150	0.045	8.3	772
9	Checks	—	57.4	650
	(Diff. for sig. odds 19:1)		27.4	Diff. insig.
10	100	0.038	19.8	535
10	250	0.038	21.8	550
10	Checks		60.6	478

to the findings that have been reported in other cases in which it has apparently been better to apply a mist which covers the plants with tiny droplets of spray. Possibly the difference is one of the feeding habits of the insect concerned as usually the greater numbers of onion thrips are found feeding in the crotches of onions into which the spray may drain from the leaves when applied in considerable quantity. The problems of volumes and pressures warrant further investigations before definite conclusions can be drawn. Meanwhile it would seem advisable to apply the spray at a rate of at least 125 gallons per acre and at 150 pounds pressure.

TARTAR EMETIC *vs.* OTHER INSECTICIDES.—During the series of investigations numerous materials have been tested,

Table 6.—Tartar emetic-sugar spray vs. other insecticides in the reduction of onion thrips populations.

TREATMENTS	NUMBER APPL.	DATE FIRST APPLICATION	THRIPS PER PLANT	YIELDS BU/ACRE
Experiment 11:				
Tartar emetic-sugar water (2-4-100) spray	6	June 13	16.0	358
Pyrocide[1]-talc (10-90) dust	4	July 10	24.0	335
Checks	—	—	51.4	329
(Diff. for sig. odds 99:1	—	—	6.6	Diff.
odds 99:1	—	—	15.3	insig.)
Experiment 12:				
Tartar emetic-sugar-water (2-4-100) spray	6	June 25	9.7	470
Sodium antimonyl hydroxyacetate[2]-sugar-water (4-4-100) spray	6	June 25	9.2	558
Checks	—	—	43.7	470
Experiment 13:				
Tartar emetic-sugar-water (2-4-100) spray	5	June 14	7.1	833
Sodium antimonyl hydroxyacetate[2]-sugar-water (4-4-100) spray	5	June 14	11.2	796
Pyrocide[1]-talc (10-90) dust	5	June 15	18.3	723
Checks	—	—	35.0	692
(Diff. for sig. odds 19:1	—	—	6.6	75)
Experiment 14:				
Tartar emetic-sugar-water (2-4-100) spray	5	June 18	8.3	411
Sodium antimonyl lactophenolate[3] (1:200+4 lbs. sugar per 100 gals.) spray	5	June 18	8.7	432
Checks	—	—	33.4	399
(Diff. for sig. odds 19:1	—	—	11.9	Insig.)

[1] Dry *Pyrocide* containing 2 per cent pyrethrins. Courtesy McLaughlin Gormley King Co., Minneapolis, Minnesota.
[2] Courtesy E. I. Du Pont de Nemours & Co., Wilmington, Delaware.
[3] Courtesy Apex Chemical Co., New York City.

and consequently in many cases indirect comparisons of their efficiencies with that of tartar emetic have been made. However, in 4 experiments direct comparisons were made as shown in table 6. Experiment 11 consisted of applications of the materials with a knapsack sprayer or crank duster to plots of 0.10 acre arranged in a latin square, thrips counts being made on 25 plants in each plot on August 4. Experiment 12 was likewise a hand-equipment experiment, but there were only 2 plots of 0.33 acre for each treatment and therefore the results were not subjected to statistical analysis. Thrips counts were made on 25 plants in each plot on August 5. In experiment 13 the sprays were applied to 6-row plots with the power sprayer at a pressure of 150 pounds and with 0.038 in discs in the nozzles. The dusts were applied on 8-row plots with a 4-row self-propelled *Messinger* duster at a rate of 25 to 35 pounds per acre depending upon the size of the onions. The 4 treatments were replicated 4 times in a random arrangement and in each plot the thrips on 25 plants were counted on July 31. Experiment 14 was another hand-equipment experiment with applications made on 0.10 acre plots arranged in a latin square. One replicate of each treatment was lost because of the labor problem involved in weeding so the analysis of the data is based on only 2 replicates of each treatment. Thrips counts were made on 25 plants in each of these plots on August 12.

All of the other materials used in the four experiments showed promise as possible substitutes for tartar emetic. Unfortunately they were not tested at times when thrips populations were very high, and in only one case, Experiment 13, were significant differences obtained between yields. Nevertheless, there were significant reductions in the insect populations on onions sprayed with these materials, and these were of sufficient magnitude to warrant further investigation.

SPRAY SUPPLEMENTS.—In table 7 are given the results of three field experiments in which various supplements were added to tartar emetic sprays. In all three the applications were made with a knapsack sprayer. The 5 treatments in Experiment 15 were replicated 4 times on plots 4 rows wide and 25 feet long. Sprays were applied on July 19 and thrips counts were taken

Table 7.—Comparisons of onion thrips control with tartar emetic-sugar sprays alone and with supplements.

TREATMENTS	THRIPS PER PLANT
Experiment 15:	
Tartar emetic-sugar-water (4-4-100)	5.9
Tartar emetic-sugar-water (4-4-100) plus 0.75 lb. *Ultrawet*[1]	8.0
Tartar emetic-sugar-water (4-8-100) plus 0.75 lb. *Ultrawet*[1]	6.3
Tartar emetic-sugar-water (4-16-100) plus 0.75 lb. *Ultrawet*[1]	5.0
Checks	9.9
Experiment 16:	
Tartar emetic-sugar-water (2-4-100)	2.9
Tartar emetic-sugar-water (2-4-100) plus 0.75 lb. *IN-181-P*[2]	3.3
Tartar emetic-sugar-water (4-4-100)	3.1
Tartar emetic-sugar-water (4-4-100) plus 0.75 lb. *IN-181-P*[2]	4.0
Checks	5.7
(Diff. for sig. at odds 19:1	1.8)
Experiment 17:	
Tartar emetic-sugar-water (2-4-100)	9.6
Tartar emetic-sugar-water (2-4-100) plus 0.75 lb. *IN-181-P*[2]	11.1
Tartar emetic-sugar-water (2-4-100) plus 0.5 lb. *Cuprocide 54*[3]	17.1
Tartar emetic-sugar-water (2-4-100) plus 0.75 lb. Karaya gum[4]	12.5
Checks	24.3
(Diff. for sig. at odds 19:1	8.3)

[1] A water-soluble monosulfate of petroleum hydrocarbons, Atlantic Refining Co., Philadelphia, Pa.
[2] About 36 per cent sodium lauryl sulfate. E. I. du Pont de Nemours & Co., Wilmington, Delaware.
[3] Cuprous oxide. Rohm and Haas Co., Philadelphia, Pa.
[4] Jaques Wolfe & Co., Passaic, New Jersey.

July 21. The 5 treatments in Experiment 16 were likewise replicated 4 times on plots 4 rows wide and 25 feet long. The sprays were applied on July 17 and thrips counts taken on July 19. The 5 treatments in Experiment 17 were replicated 5 times in a latin square of plots of the same size as in the two preceding experiments. Applications of sprays were made on July 18 and 29, and counts of thrips on 10 tagged plants in each plot were taken on August 6.

The thrips populations in all three of the above experiments were very low. However, in two of them significant differences were obtained between sprays with and without supplements, and in the remaining test the same general trend was observed. While it would probably be unwise to conclude from these tests that the supplements actually reduced the efficiency of the tartar emetic sprays, there were certainly no indications of their be-

ing of such value as to justify their use. Further support to this belief was added by results obtained in a factorial-design greenhouse experiment on potted onions. In this test 4 supplements were given trials in sprays containing three levels of tartar emetic and two of sugar, and again there seemed to be no advantage gained by addition of the supplements.

SUMMARY AND CONCLUSIONS.—During the past 5 years tartar emetic has proven satisfactory in sprays against the onion thrips in New York. In many instances, however, insect populations have been so low that reductions in numbers due to spraying have not resulted in corresponding increases in yields of onions. Various phases of the problem need further investigation but from experiments thus far conducted it would seen advisable to make 5 to 6 applications of tartar emetic-sugar-water (2-4-100) spray at about 6-day intervals beginning early in the season when the onions are 4–6 inches high. The spray should be applied at a rate of at least 125 gallons per acre and at a spray pressure of 150 pounds. The use of wetters or spreaders does not seem warranted, but other insecticides such as sodium antimonyl lactophenolate, sodium antimonyl hydroxyacetate, and pyrethrum do seem to offer definite possibilities.

Obviously the following of the above spray schedule is a matter of insurance based on the residual effect of the spray as applications are made before the thrips populations have reached damaging proportions. It affords a considerable advantage in that it permits the conclusion of spraying operations before the onions, which are usually grown in 14- to 16-inch rows on New York mucklands, have attained sufficient growth to be severely damaged by the sprayer. It is quite true that there are some years in New York in which the thrips populations do not attain high levels because of natural factors, and that in such years the costs of labor and material would be lost. However, in view of the cheapness of materials, the increased value of onions in years when damage is severe, and the normally high value of particular crops such as those raised for seed, such a spray program would seem to be economically sound. 12/30/43

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PUBLISHED PROCEEDINGS SOUTHERN WAR CONFERENCE ON ENTOMOLOGY

The entire proceedings of the Southern War Conference on Entomology will be released in mimeograph form June 1, 1944. This conference was sponsored by the Cotton States Branch of the American Association of Economic Entomologists.

Six major symposia were held during the conference. These were as follows: Cotton Insect Control, The Control of Pests Affecting the Health and Comfort of Man and Domestic Animals, The Control of Pests of Field Crops and Stored Grain or Seed, Fruit Insect Control, Insecticides and Machinery, and The Control of Pests of Commercial Vegetables and Victory Gardens.

Cotton States Branch members will be furnished a copy of the proceedings free, and others may obtain a copy by forwarding one dollar and twenty-five cents to the Secretary-Treasurer of the Branch, John T. Creighton, University of Florida, Gainesville, Florida.

Cpl. W. W. Abramitis (32387137) may be addressed care of Detached Medical Department, Station Hospital, Camp Sibert, Alabama—CORRECTION—*Lieutenant* Walter W. Abramitis, Sn. Corps, address 37 Malaria Survey Unit, Camp Planche, New Orleans, La.—12—, Expects to be overseas soon.

PACIFIC SLOPE BRANCH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The 29th Annual Meeting of the Pacific Slope Branch will be held at the University of California at Berkeley, California, on June 27 and 28, 1944.

The meeting will be streamlined, and long, miscellaneous paper-reading sessions will be eliminated. The theme of the meeting will be "Wartime and Postwar Entomology." Invitational addresses will be given by prominent men in the entomological field. Sessions will be devoted to such topics as the following:

The Effect of the War on Agricultural Entomology
The Effect of the War on Medical and Veterinary Entomology
Pacific Coast Quarantine Problems
The Insecticide Situation, including New or Substitute Insecticides
Postwar Entomological Problems

A. J. FLEBUT, *Chairman*
Richmond, California

ROY E. CAMPBELL, *Secretary*
Alhambra, California

Capt. Roger L. Pierpont wrote from Italy early in the year instructing the Secretary to send his JOURNAL to his home in Wilmington, Delaware. (1201 Delaware Ave., Wilmington 19). Letters would doubtless reach him through that address.

The Effect of Methyl Bromide Fumigation on the Subsequent Development of the Croft Lily[1,3]

E. P. Breakey[2]

When considering the possible use of methyl bromide (CH_3Br) fumigation as a control for the bulb mite, *Rhizoglyphus hyacinthi* Bdv. on lilies, the effect of the fumigation on the subsequent development of the plants was seriously questioned. Answers to the questions asked were apparently not to be found in the literature, so the following studies were initiated for the purpose of obtaining some of the desired information.

Materials and Methods.—One thousand selected bulbs (7's–8's) of the Croft variety of the Easter lily, *Lilium longiflorum* Thunb., were obtained through the generosity of Mr. Vic Morgan, an interested grower. The bulbs were delivered on October 5, 1941, and 900 of them were reselected and divided into lots of 100 each. Each lot was weighed, placed in a mesh bag, and given an identifying number.

When setting up a schedule of treatments, it was decided to follow the one used by Mackie (Mackie *et al.*, 1942) and his associates, with certain modifications. Mackie and his associates were concerned with the use of methyl bromide fumigation as a control for the gladiolus thrips, *Taeniothrips simplex* Mor., and the effect of fumigation on the subsequent development of the gladiolus. The results of this work have since been published (Steinweden *et al.*, 1942).

The following schedule of treatments was followed, subjecting one bag of 100 bulbs to each treatment:

Table 1.—Schedule of treatments, fumigations October 6–11 inclusive.

Treatment	Lbs. CH_3Br per 1000 Cu. Ft.	Hours Exposure	Temperature Degrees F.
A-1	0	—	—
A-2	2	2	70
A-3	2	2½	70
A-4	2	3	70
A-5	3	2	70
A-6	3	2½	70
A-7	3	3	70
A-8	3	4	70
A-9	Standard HCN as used for Narcissus Bulb Fly.		

It will be noted that all treatments were made at 70° F. whereas Mackie and his associates used 80° F. It seemed advisable to employ the lower temperature, since it would be easier to maintain in a fumigation chamber in western Washington under the atmospheric conditions prevailing at that season of the year. All treatments were made in a standard fumigation chamber of 500 cubic feet capacity with air circulation and temperature control. The standard HCN treatment was that currently in use for the control of the narcissus bulb fly, *Merodon equestris* Fabr. (Doucette 1941).

All bulbs were planted on October 13, 1941 within a few days following fumigation. The bulbs were planted in a good sandy loam soil, each lot of 100 bulbs being planted in a single row. Careful records were kept of the subsequent development of the plants.

Results.—*Growth:* It is desirable to discuss the effect of the various treatments on the growth and development of the lilies in some detail. In general, the effect was that of apparent stimulation. By the end of December, a number of the lilies were pushing through the soil when the approach of cold weather made it advisable to cover the growing tips. It was noted that the number of plants showing above the soil began with the third treatment (A-3) (2 lbs. CH_3Br for 2.5 hrs.), and increased uniformly as the schedules increased (Fig. 1). A record was made of the number of plants showing above the ground on December 29, 1941 just before plowing additional soil over the growing tips.

By March 20, 1942 the stimulative effect of the various treatments had apparently shifted to the lower schedules, the optimum being A-3 (2 lbs. CH_3Br for 2.5 hrs.) (Fig. 1). The higher schedules, treatments A-6, A-7 and A-8 were scarcely on a par with the check, A-1. This effect was no longer apparent on May 1, 1942 when

[1] Published as Scientific Paper No. 595, College of Agriculture and Agricultural Experiment Stations, State College of Washington, Pullman.

[2] Research Entomologist, Washington Agricultural Experiment Stations.

[3] This paper has been granted prompt publication on payment of the costs of printing.

the total number of plants up varied little from treatment to treatment with the exception of A-8 (3 lbs. CH_3Br for 4 hrs.) where only about 70 per cent of the bulbs planted came up (Fig. 1). All bulbs in treatment A-9 (Standard HCN) promptly rotted, though narcissus bulbs of the King

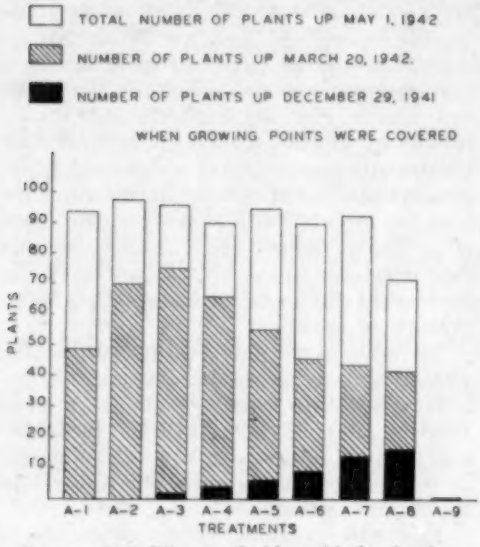
TOTAL NUMBER OF PLANTS UP MAY 1, 1942
NUMBER OF PLANTS UP MARCH 20, 1942.
NUMBER OF PLANTS UP DECEMBER 29, 1941
WHEN GROWING POINTS WERE COVERED
PLANTS
TREATMENTS
A-1 A-2 A-3 A-4 A-5 A-6 A-7 A-8 A-9

FIG 1.—Croft lilies, methyl bromide fumigation, 1942. Growth data.

Alfred variety which were fumigated simultaneously with the lilies in A-9, and which had been planted near by, were apparently unaffected by the treatment.

The stimulative effect was again evident at blossoming time in July, and corresponded closely to the effect on the growth of the plants as already noted. The criteria used in ascertaining this effect

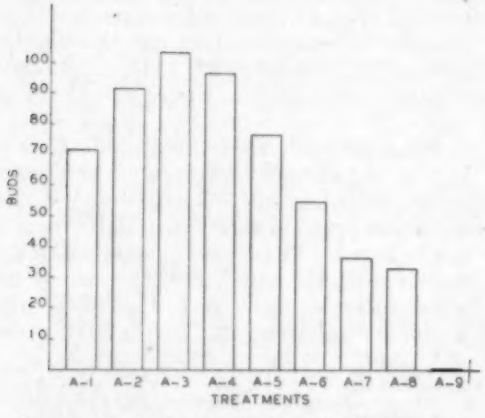

FIG. 2.—Croft lilies, methyl bromide fumigation, 1942. Growth data—Number of buds July 6.

were the number of buds present on July 6, 1942 (Fig. 2), the number of flowers open on July 24 (Fig. 3), and the height of the flowering stalks (Fig. 4). The height of the flowering stalks was determined by measuring the distances from the bases of the flowers to the surface of the soil and determining an average for each treatment.

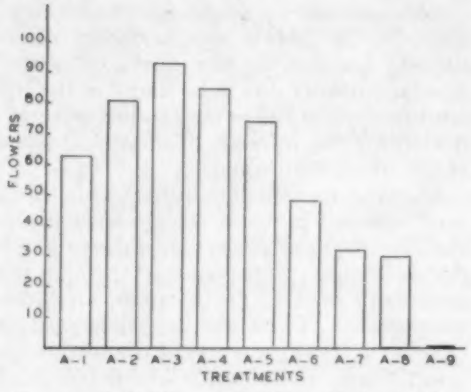

FIG. 3.—Croft lilies, methyl bromide fumigation, 1942. Growth data—Number of flowers July 24.

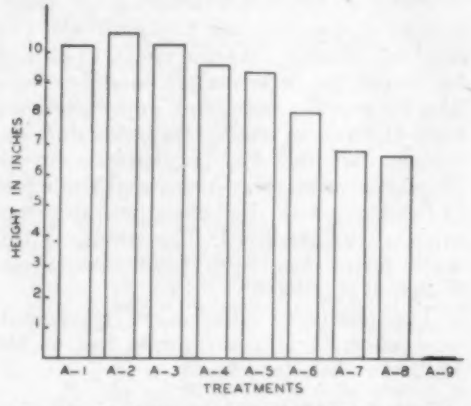

FIG. 4.—Croft lilies, methyl bromide fumigation, 1942. Growth data—Height of flowering stalks.

Yield: When the percent increase in the weights of the bulbs harvested over the weights of those planted was determined, the apparent stimulative effect was again evident, treatment A-3 (2 lbs. CH_3Br for $2\frac{1}{2}$ hrs.) again giving optimum results. (Fig. 5). On the basis of the stem bulblets produced, however, the optimum appears to shift slightly in favor of the lower schedule A-2 (2 lbs. CH_3Br for 2 hrs.) (Fig. 6).

DISCUSSION.—The bulbs used in these studies were apparently free from infesta-

tion by the bulb mite, *Rhizoglyphus hyacinthi* Bdv. However, Mackie and his associates (1942) found that adults and young of the bulb mite were killed at a schedule as low as 3 lbs. CH_3Br for 2 hrs. at 75° F., but that some eggs survived in all tests used, even as high as 3 lbs. CH_3Br for 5 hrs. Note that the lower schedule, 3 lbs. CH_3Br for 2 hrs. at 75° F. is practically the same as the treatment A-5 used in these studies. Because of the resistance of the eggs, two treatments from 10 to 14 days apart would be necessary for complete control. Just what effect such multiple treatments would have on the subsequent growth and development of the lilies has not been determined.

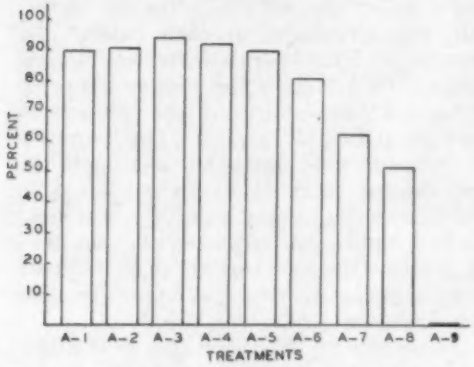

FIG. 5.—Croft lilies, methyl bromide fumigation, 1942. Harvest data—Increase in weight of mother bulbs.

The results of Garman's exhaustive study of the bulb mite and its control (Garman 1937) are far from encouraging, particularly when considered as applicable to the lily. It is extremely doubtful if the thermal treatments recommended for the control of the mite on narcissus could be applied successfully to the control of the pest on the lily. A successful bulb grower made the statement recently that he would still be in the lily business had he been able to control the bulb mite. The results of the studies reported in this paper indicate that methyl bromide fumigation may be the solution to this problem and that it should be possible for the grower of lilies to work out a schedule which will give him optimum results.

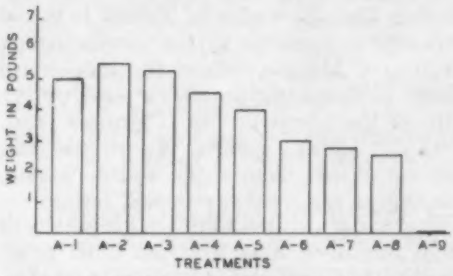

FIG. 6.—Croft lilies, methyl bromide fumigation, 1942. Harvest data—Weight of stem bulblets.

SUMMARY.—Selected bulbs of the Croft variety of the Easter lily, *Lilium longiflorum* Thunb. were fumigated with methyl bromide at various schedules to determine the effect of this fumigant on the subsequent growth and development of the plants. In general, the effect was apparently that of stimulation. The higher schedules were injurious while the lower schedules were beneficial. Bulbs subjected to the following schedules at 70° F. were definitely benefited: 2 lbs. CH_3Br for 2 hrs.; 2 lbs. CH_3Br for 2.5 hrs.; 2 lbs. CH_3Br for 3 hrs.; and 3 lbs. CH_3Br for 2 hrs. Schedule A-3, 2 lbs. CH_3Br for 2.5 hrs. gave optimum results as based on the subsequent growth and development of the lilies. —2-28-44.

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Studies on the Response of Fruitflies to Temperature

E. W. Baker, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

The data here presented concern three species of fruitflies. One of these, *Anastrepha ludens* (Loew), is a serious pest of citrus and mango in Mexico and in recent years has become an important factor in the Rio Grande Valley of Texas. It is apparently indigenous to the northeastern section of Mexico, where the larvae are found in *Sargentia greggii*, a wild native fruit of the citrus family (Plummer *et al.* 1941). A second species, *Anastrepha serpentina* Wied., is a more southern one, ranging as far south as Brazil, but in recent years it also has appeared in Texas in large numbers. The fruits it most commonly attacks are *Calocarpum mammosum*, *Achras sapota*, and *Chrysophyllum cainito*, but larvae have also been found in orange and grapefruit. The third species is here designated "Mexican *Anastrepha mombinpraeoptans*" to distinguish it from *A. mombinpraeoptans* Sein which was described from Puerto Rico. A. C. Baker[2] has pointed out that Sein's species represents the West Indian counterpart of the Mexican form, that it differs in habits and structure, and that it would seem wisest therefore not to consider the two identical as does Alan Stone (1942). The Mexican form attacks jobo in Morelos and *Eugenia jambos* and *Spondius mombin* in the vicinity of Cordoba, Vera Cruz. It readily infests California plums in the laboratory, and oviposition in guavas in the laboratory commonly occurs although no larval development has been noted. It is rarely found infesting mangoes in Morelos and similar regions, whereas the Puerto Rican species is a serious pest of mangoes in that Island. The *A. monbinpraeoptans* employed in the study here reported were obtained from Jiutepec, Morelos. Near the City of Veracruz, according to Dr. A. C. Baker, an *A. mombinpraeoptans* may be found infesting mangoes, but as yet no study has been made with the form occurring there.

Methods.—Groups of 50 flies of each sex were taken 4 to 10 hours after emergence and kept in small cheesecloth-covered cages, and were given the usual diet of water, sugar, and orange sections, and suitable fruit-skin sections were supplied for oviposition. The cages were 8 inches square and each had a wooden floor and a sliding glass door. These cages were placed in various cabinets maintained at 10°, 15°, 20°, 25°, 30°, and 35° C. by light bulbs to within ± 0.1 Centigrade degree. Air was circulated in each cabinet by means of fans operated by an electric motor. To maintain the proper temperatures, ice was required in the cabinets to be kept at 10°, 15°, and 20°. The humidity in these cabinets, due to the melting of the ice, ranged from 28 to 78 per cent. In cabinets without ice, humidity was held at 65 ± 5 per cent by means of open pans of water. Observations seem to indicate that a moderate range in humidity does not have much effect on the fly.

Discussion.—For each species the time in days has been plotted against the probit of per cent dead of both sexes at each temperature and the curves are shown in figures 1 to 3.[3] In all cases the high (35° C.) and the low (10° C.) temperatures gave curved lines, whereas the intermediate temperatures gave straight lines. Since longevity extended over many days, the spacing of the time interval is necessarily crowded, and consequently the points for mortality occurring before 30 days are somewhat crowded. When the data for the two extremes are plotted in logarithm of days versus probit of per

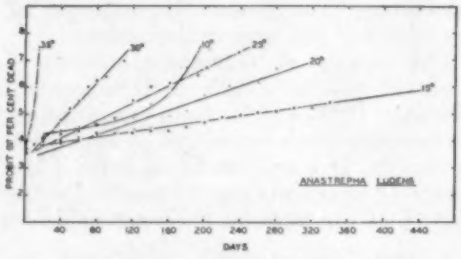

Fig. 1.—Regression lines for the longevity of *Anastrepha ludens*.

[1] The writer acknowledges his appreciation of helpful suggestions by D. F. Starr.

[2] Baker, A. C., W. E. Stone, C. C. Plummer, and M. McPhail. A review of studies on the Mexican fruitfly and related Mexican species. (In course of publication as U. S. Dept. Agr. Misc. Pub. 531.)

[3] Owing to a breakdown in the equipment the temperature in the 15° cabinet with *A. serpentina* rose to 40° C. on the 182nd day, killing the flies that were left. This accounts for the shortened regression line.

cent dead (Figs. 4 and 5), the resulting lines are straight, as has been found in toxicity studies with *Anastrepha ludens*,[1] whereas the data plotted in the same manner for the intermediate temperatures (not shown in the graphs) give curved lines. These latter straight lines would indicate that the high and low temperatures are predominantly lethal factors, whereas the intermediate temperatures are temperatures to which normal activity is adjusted, a distinction made by A. C. Baker[2] in connection with regressions from toxic and nontoxic materials.

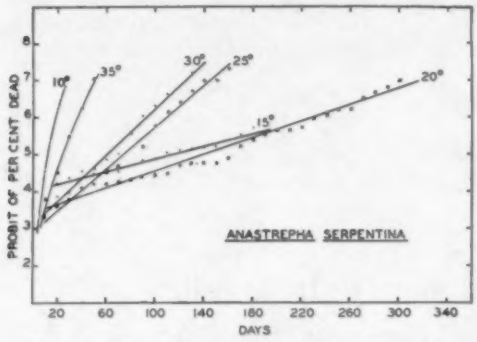

FIG. 2.—Regression lines for the longevity of *Anastrepha serpentina*.

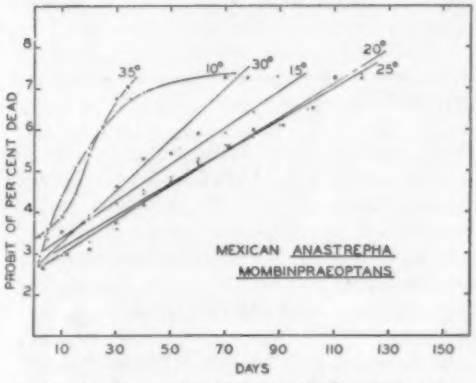

FIG. 3.—Regression lines for the longevity of "Mexican *Anastrepha mombinpraeoptans*."

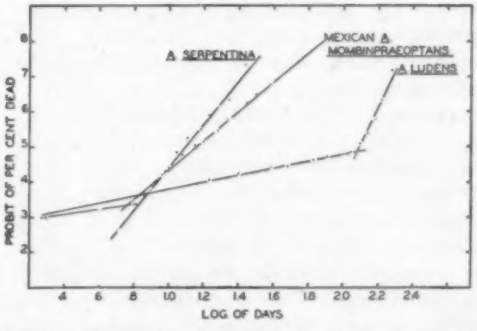

FIG. 4.—Regression lines for the three species at 10° C. using the logarithm of days versus probit of per cent dead.

[1] Plummer, C. C. Unpublished data.

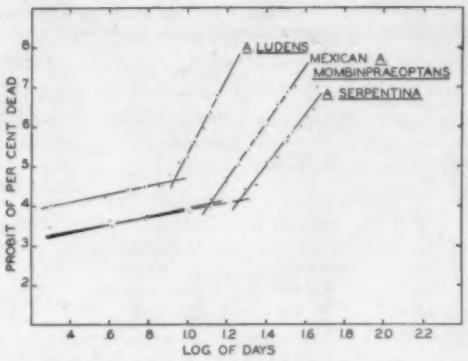

FIG. 5.—Regression lines for the three species at 35° C. using the logarithm of days versus probit of per cent dead.

Stages in the life history of the three species for the selected temperatures are summarized in table 1.

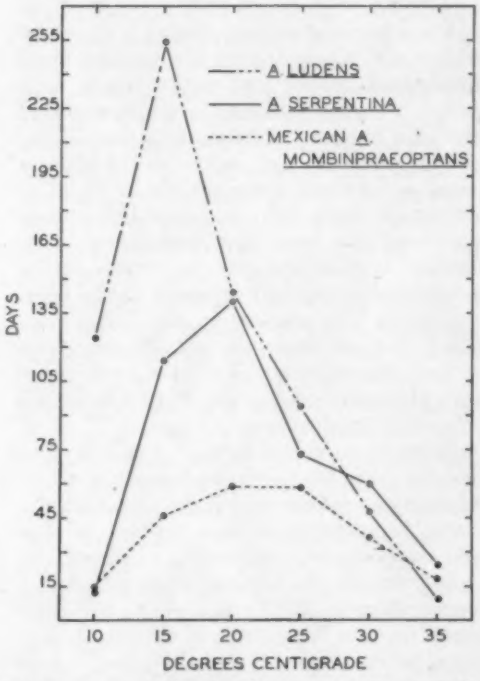

FIG. 6.—A graph showing the comparative susceptibilities of the fruitflies to the various temperatures on the basis of the 50 per cent survival point.

[2] See footnote page 280.

Table 1.—Summary of effects of temperature on fruitfly adults.

TEMPERATURE	HUMIDITY	ACTIVITY	MINIMUM PRE-OVIPOSITION PERIOD	OVIPOSITION PERIOD[1]	TOTAL EGGS LAID PER CAGE	MEDIAN OF SURVIVAL
°C.	Per Cent		Days	Days	Number	Days
			Anastrepha ludens			
10	55–65	Slight	—	—	—	124
15	50–66	Some	62	113	37	254
20	40–75	Moderate	24	84	683	144
25	62–67	Moderate	17	51	1492	94
30	63–68	Very active	11	39	985	48
35	63–68	Excited	—	—	—	9.6
			Anastrepha serpentina			
10	62–78	Slight	—	—	—	12
15	55–78	Some	—	—	—	114
20	28–50	Moderate	64	7	55	140
25	63–68	Moderate	37	29	37	73
30	63–68	Very active	17	64	1484	60
35	63–68	Excited	—	—	—	24
			Mexican *Anastrepha mombinpraeoptans*			
10	62–78	Slight	—	—	—	14.5
15	55–78	Some	—	—	—	46
20	73–78	Moderate	49	22	2	59
25	63–68	Moderate	20	107	111	58
30	63–68	Very active	—	—	—	36.5
35	63–68	Excited	—	—	—	18.5

[1] The period includes the time from the first to the last egg laid by each group of flies.

A comparison among species is made by arbitrarily taking the 50 per cent survival point (median) for each temperature, as is shown in figure 6. Because of the slopes of the lines, points taken much above or below this 50 per cent value would show a trend somewhat different from that illustrated. Although the two sexes were combined to give the regression lines, studies were made on the comparative susceptibility of the two sexes to the temperatures. Chi-square, at the 5 per cent point, did not show any significant trend to indicate that either males or females were the more susceptible throughout the series of temperatures.

From figure 6 and table 1 it can be seen that at the 50 per cent survival point *Anastrepha ludens* is longer lived at the lower temperatures than either of the other species, but succumbs in about the same time at the higher temperatures. A temperature of 15° C. is close to the optimum for the longevity of adults (6 flies alive more than 14 months after emergence (Fig. 1), whereas 25° to 30° is optimum for the number of eggs laid. At the same point *A. serpentina* is an intermediate species as regards the life span of adults at the milder temperatures, but is shorter lived than *A. ludens* at the lower temperatures. At the 50 per cent point Mexican *A. mombinpraeoptans* is shorter lived at the milder temperatures, more or less the same as the others at the higher temperatures, and above equal to *A. serpentina* at 10° C.

As worked out in the laboratory *Anastrepha ludens* showed the longest developmental period, followed by *A. serpentina*, and with Mexican *A. mombinpraeoptans* the shortest. This order appears to hold in the longevity and oviposition studies at the intermediate temperatures.

These studies substantiate field observations on at least two of the species.[1] In Cuernavaca (elevation 4750 ft.), Morelos, which is relatively cooler than nearby Yautepec (elevation 3750 ft.), the mangoes are heavily infested with *Anastrepha ludens*, whereas jobos are only lightly infested with Mexican *A. mombinpraeoptans*. However, in warmer Yautepec the mangoes are only moderately infested with *A. ludens*, while jobos are heavily infested with Mexican *A. mombinprae-*

[1] See footnote on page 280.

optans. This record is borne out by the optimum for longevity at constant temperatures in the laboratory. Oviposition studies have not shown this, as the specimens of Mexican *A. mombinpraeoptans* are difficult to work with and do not oviposit readily in the laboratory. Field data on *A. serpentina* are still too scattered to use for comparisons.

SUMMARY.—The major host range of *Anastrepha ludens*, *A. serpentina*, and Mexican *A. mombinpraeoptans* are given. Methods used in the longevity study are described. Results obtained demonstrate that *A. ludens* lives longer than the other species at the lower temperatures, that *A. serpentina* is an intermediate species as regards longevity, and that Mexican *A. mombinpraeoptans* is the shortest lived at the intermediate temperatures. —1-18-44.

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Tests of Repellents against Chiggers[1,2]

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The military authorities in the Division of Preventive Medicine recognize the fact that chigger bites on men in the field constitute a serious problem because of the intense itching, frequently with subsequent infection, loss of sleep, and general lowering of morale. Large numbers of men in various parts of the country are affected during training and maneuvers. Furthermore, Chandler (1940) states that species of chiggers occurring in the Far East transmit a typhus-like disease. In Japan the disease is called river fever or flood fever and is carried by *Trombicula akamushi* (Brumpt). A similar disease has been reported also from Burma, Malay States, Sumatra, Formosa, Korea, Indo-China, and southern China. Troops may come in contact with the vectors of the disease, and the value of a good chigger repellent is evident.

Chiggers occur in practically all the tropical, subtropical, and temperate regions of the world. In the United States they are normally most abundant in damp places with rank vegetation, such as the margins of streams, ponds, swamps, or woods, and they may be found readily on fallen logs or smaller pieces of wood lying on the ground in such areas. However, chiggers may occur in other areas, and are frequently a pest on lawns,p arade grounds, and parks. They may be seen moving about on the shoes when one is standing in an infested spot.

Man is attacked by the larval stage of the mite, and it is this stage that is called the chigger. It is circular in outline, bright red, possesses six legs, and is about the size of the point of a common pin. The chigger is omnivorous and feeds on a variety of warm-blooded and cold-blooded animals. After engorging, it drops to the ground and transforms to the nymphal and subsequently to the adult form. The nymphal and adult stages feed on decaying organic matter exclusively.

Chiggers usually reach the body by crawling up the legs and arms, since they cannot penetrate tightly woven clothing. They then run rapidly over the skin, seeking, a favorable place for attachment, such as an area where the epidermis is thin or along the garter or belt line, according to Parkhurst (1937). Attachment is effected by inserting the mouth parts just beneath the skin, and even though the chigger is removed shortly after attachment the itching persists for several days. Thus the importance of preventing attachment is apparent.

Studies on chigger repellents were conducted at Orlando, Fla., in 1942 for the purpose of determining what materials could be used by the armed forces to protect individuals against attack by these

[1] The data included in this paper were obtained in connection with investigations conducted under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the Bureau of Entomology and Plant Quarantine.

[2] *Acariscus* and *Eutrombicula* spp.

pests. The most prevalent species in the area is *Acariscus masoni* (Ewing),[3] but an appreciable number of tests were made against *Eutrombicula tropica* (Ewing.)[3] Through the cooperation of R. W. Wells and E. W. Laake, some tests were also made against the common North American chigger *Eutrombicula alfreddugesi* (Oud.)[3] in the vicinity of Dallas, Tex.

This report summarizes briefly the results obtained with powders, ointments, and liquids applied to the skin, and with liquid repellents applied to the clothing. Of the two methods of application, the latter proved far more effective and practicable, and resulted in the recommendation of an effective chigger repellent.

TESTING METHODS.—All tests were made in the field under natural conditions. In the early stages of the investigation the materials were applied to the skin from the waist down to the feet, and in the case of the powders a small amount was dusted into the shorts and socks. Test volunteers treated themselves by applying the materials to the lower part of the legs and in the socks. As the work progressed, a change was made to application of dust and liquid treatments to the socks alone, and finally to treatment of the outer clothing with liquid materials applied in a half-inch band to the inside of the bottoms of the legs, waist, and fly of the trousers, the cuffs, fly, and neck of the shirt, and around the upper part of the socks.

The test subjects were exposed for periods averaging approximately 2 hours in areas heavily infested with chiggers. Then they were examined, and a careful count was made of all attached chiggers. In each test a number of untreated subjects were exposed as checks. In the inital tests the subjects were exposed directly after treatment, but in the later critical tests exposure was delayed for 24 hours, and in some of the tests of sock and clothing treatments a number of exposures were made up to 30 or more days after application of the repellent. In the majority of tests the subjects stood or walked about in the infested area, but all tests of treated clothing were made with the subjects either sitting or lying down.

A total of 323 tests were completed with materials applied to the skin as described above. Twenty-eight different materials and combinations of materials and 8 dilutions of those most promising were included in these tests. Three of these materials were liquids, one was an ointment, and the rest were powders. In all these short-term tests the subjects were exposed shortly after treatment.

DISCUSSION OF RESULTS.—A summary of the results as shown in table 1. The fol-

[3] Determined by H. E. Ewing.

Table 1.—A summary of the results obtained with certain chigger treatments, Orlando, Fla., May–September, 1942.

MATERIAL	NUMBER OF TESTS	AVERAGE NUMBER OF CHIGGERS ATTACHED TO TREATED SUBJECTS	AVERAGE NUMBER OF CHIGGERS ATTACHED TO UNTREATED SUBJECTS
Dusts:			
Orlando louse powder (MYL)[1]	7	0	39.4
Rotenone, 2%, in pyrophyllite	6	0	21.4
Pyrethrins, 2%, in pyrophyllite	16	0.1	21.4
Pyrethrins, 0.25%, plus N-isobutyl-undecylenamide, 1%, in pyrophyllite	14	.1	19.3
Dimethyl phthalate, 20%, in pyrophyllite and tricalcium phosphate	22	.1	19.3
Pyrethrins, 0.5%, in pyrophyllite	8	7.4	21.4
Indalone, 10%, in pyrophyllite	2	11.5	21.4
Pyrethrins, 0.5%, plus sesame oil, 1%, in pyrophyllite	8	13.9	21.4
Pyrethrins, 1%, plus sesame oil, 2%, in pyrophyllite	2	24.5	21.4
Sulfur	18	1.7	17.7
Liquids:			
Dimethyl phthalate	9	0	21.4
Camphor, 1.5%, menthol, 1%, and mineral oil, 98.5%	3	18.7	13.7

[1] Pyrethrins, 0.2%; dinitroanisole, 2%; N-isobutylundecylenamide, 2%; *Phenol S* (isopropyl cresols), 1%; and pyrophyllite, 94%.

lowing gave complete protection: The louse powder MYL, developed at the Orlando, Fla., laboratory; dimethyl phthalate used as a liquid; and 2 per cent of rotenone in pyrophyllite. The limited number of attachments recorded in 16 tests with 2 per cent of pyrethrins in pyrophyllite indicate that this material is probably equally effective. Powder containing 1 per cent of pyrethrins (impregnated on talc by using 20 per cent pyrethrum concentrate) appeared to be much less effective, whereas a powder containing 0.25 per cent of pyrethrins plus 1 per cent of N-isobutylundecylenamide gave results similar to those obtained with powders containing 2 per cent of pyrethrins without the activator. It appears, therefore, that this activator incorporated with pyrethrum powders, as noted in the body louse project, increases markedly the effectiveness of pyrethrum against chiggers. However, sesame oil, another well-known synergist used in fly sprays, apparently has no such effect when used in pyrethrum powders against chiggers.

Dimethyl phthalate at a concentration of 20 per cent in a powder gave results comparable with the better powder treatments. A powder containing 10 per cent of *Indalone* (n-butyl mesityl oxide oxalate) proved relatively ineffective.

Sulfur dusted in the clothing has been the recommended chigger-repellent treatment for a number of years. Tests with this material showed that it was usually effective for several hours but was somewhat erratic and undependable. Weigel (1942) reports that sulfur causes dermatitis in some individuals, and many consider the odor objectionable.

Certain materials were given a more critical test by delaying exposure of the test persons until 24 hours after treatment. *Indalone* and dimethyl phthalate applied as a liquid to the skin, MYL louse powder, and a powder containing 1 per cent of rotenone (5 per cent derris resinate containing 20 per cent of rotenone) gave a high degree of protection under these conditions. However, results with these materials were indicated to be somewhat uncertain, especially when the subjects were lying down or crawling about in chigger-infested areas.

Further investigations of liquid and powder treatments applied to the skin were suspended when liquid repellents applied directly to the clothing were indicated to be far more effective. Socks

Table 2.—Results of tests of clothing treated with various chigger-repellent materials, Orlando, Fla., and Dallas, Tex., August-October, 1942.

Days between Treatment and Exposure	Material	Suits Tested	Chiggers Attached to Protected Subjects	Chiggers Attached to Untreated Subjects
3	Dimethyl phthalate (pure liquid)	5	0.6	51.7
16	Dimethyl phthalate (pure liquid)	4	0	26.0
23	Dimethyl phthalate (pure liquid)	4	0	104.5
30	Dimethyl phthalate (pure liquid)	4	0	200.5
	25 per cent solutions:[1]			
2	Dimethyl phthalate	1	0	236.0
	Rutgers 612	1	1	236.0
9	Dimethyl phthalate	1	0	263.0
	Rutgers 612	1	0	263.0
20	Dimethyl phthalate	2	0	32.5
	Indalone	2	0	32.5
	Rutgers 612	2	0	80.5
24	Dimethyl phthalate	2	4.5	231.0
	Indalone	2	1.5	231.0
27	Dimethyl phthalate	2	0	124.0
	Indalone	1	0	124.0
	Rutgers 612	2	0	124.0
30	Dimethyl phthalate	2	2.0	86.0
	Indalone	2	3.0	86.0
	Rutgers 612	2	14.0	86.0
34	Dimethyl phthalate	2	0	28.0
	Indalone	2	0	28.0
	Rutgers 612	1	0	28.0

[1] The solvent for dimethyl phthalate was benzene; for *Indalone* and *Rutgers 612*, Stoddard solvent.

dipped in solutions consisting of either 25 per cent of dimethyl phthalate in benzene, or 25 per cent of *Indalone*[1] in *Stoddard Solvent*[1] (a petroleum distillate with approximate boiling point of 350°–400° F.), or 25 per cent of *Rutgers 612*[1] (2-ethylhexanediol-1, 3) in *Stoddard Solvent*, gave protection up to 39 days after application, whereas undiluted dimethyl phthalate gave complete protection up to 59 days after application. All other materials tested in this manner gave protection for much shorter periods.

In order to be of the greatest value to the armed forces, a repellent must afford protection from chigger attack whether one is walking, sitting, or lying in an infested area, which would not be possible if treatments were limited to the socks. For this reason tests were conducted of liquid repellents applied to all the openings in the clothing through which chiggers might find access to the body. The method of applying the materials and exposing the subjects has been described previously. Twenty-three tests were completed, and the results are presented in table 2. It will be seen that all the repellents tested were about equally effective in providing long-term protection. Dimethyl phthalate, less objectionable to use, more readily available and less expensive than the others.

Through the efforts of W. G. Bruce, liaison agent an opportunity was afforded to observe the results obtained with MYL louse powder, dimethyl phthalate, and *Indalone* under Army-maneuver conditions in northwestern Louisiana. Small cans of the powder and 2-ounce bottles of dimethyl phthalate were distributed among the officers and men of several units, and brief instructions were given on the method of application. The *Indalone* was applied with a hand sprayer to the clothing of a number of officers and men belonging to another unit. A check-up was made 4 days later, and it was found that almost complete protection had been obtained with dimethyl phthalate applied from the bottles and with the *Indalone* spray, while about 70 per cent of the men treated with MYL louse powder had been infested. It is extremely difficult to apply a powder to all parts of the body so as to obtain complete protection for several days. The results of this practical test substantiated previous findings that treatment of the clothing with a liquid, particularly with dimethyl phthalate, is the most effective means of obtaining protection against chigger attack over prolonged periods. The better skin treatments shown in table 1 should provide protection for periods not exceeding 1 day.

SUMMARY.—Investigations of repellents for chiggers were conducted at Orlando, Fla., to develop an effective treatment for use by the armed forces in the prevention of chigger attack. These investigations included studies on the relative effectiveness of powders, liquids, and ointments applied to the skin and of liquids applied to the clothing. Treatment of clothing was found to be the most effective and gave the longest protection, even when the test subjects were seated or lying on the ground in heavily infested areas. The most practical means of treating the clothing is to apply the liquid repellents from a small-mouth bottle in a half-inch band around the inside of the waist, the fly, and the bottoms of the legs of the trousers, the cuffs, fly, and neck of the shirt, and in a wide band around the upper part of the socks. Clothing treated in this manner with dimethyl phthalate, *Indalone*, or *Rutgers 612* gave good protection up to 30 days after treatment. However, for practical reasons, including greater desirability for use, cheapness, and availability, dimethyl phthalate is considered the most satisfactory repellent for this purpose.—3-13-44.

[1] These materials are sold under trade designations. The results reported are based on the particular sample received, and assurance cannot be given that there will not be variation between lots..

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The Effects of Infrared Radiation on Certain Insects[1]

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Little information is available on the effects of infrared radiation upon insects. MacLeod (1941 and 1943) shows the effects of these rays upon the American cockroach but makes no mention of the causes of death. Headlee and Jobbins (1938) give some figures on the transmission of infrared through the wings and integument of the American cockroach, also through thin layers of various wheat products. Since infrared rays may have a practical application in the control of certain insects, especially those infesting stored grains, a number of observations have been made by the writers. The purpose of these tests was to determine the lethal exposure, and if possible, the cause of death, when insects are exposed to infrared radiation. Tests were conducted particularly on the larvae and adults of the confused flour beetle, *Tribolium confusum*, and the mealworm, *Tenebrio molitor*, although a few tests were conducted with the eggs of the milkweed bug, *Oncopeltis fasciatus*, the adults of the bean weevil, *Acanthoscelides obtectus*, and of the black carpet beetle, *Attagenus piceus*.

Methods.—A wooden frame approximately 15 by 18 by 27 inches was constructed with two movable boards, the upper one with a 2-inch square opening to support the filter and the lower one with an opening 95 mm. in diameter to support a petri dish in which the insects, to be tested, were placed. Both boards were supported on pegs in holes drilled at inch intervals to permit adjustment. The first two tests were conducted with the apparatus set up in this fashion. As the distance between the infrared lamp and the insects was shortened, it was found more convenient to eliminate the upper board and place the filter immediately on the top of the petri dish containing the insects. Then a smaller petri dish, measuring 5 cm. in diameter, was used, which was placed on a glass plate over the original opening. The only background in all the tests was the dark linoleum covered floor 20 inches below the tip of the infrared lamp. In most of the tests the insects were placed in petri dishes with the infrared filter on top. This introduced an undesirable factor which later was overcome. At a given exposure, the temperature is slightly higher within the chamber than in the open. A few tests were conducted with the filter an inch above the chamber. Under these conditions the time required to kill mealworm larvae was increased from 14 to 18 seconds (Fig. 3).

Three different types of lamps were used. One test was conducted with a 300 watt tungsten lamp but no larvae were killed even at an exposure of 5 minutes, at a distance of 5 inches. These conditions far exceed those necessary to kill insects by infrared radiation. In four tests, as indicated in table 1, a bulb with amber glass was used. All other tests were conducted with a silvered infrared lamp of clear glass labelled, 120V-385 W. This lamp gave readings of 3.18 amperes and 114 volts or, actually, 362 watts. The accompanying chart (Fig. 1) showing the energy distribution of this infrared lamp

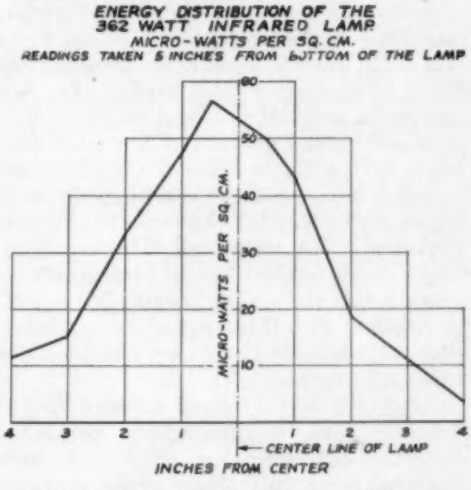

Fig. 1.—Energy distribution of the 362 watt infrared lamp.

in micro-watts per square centimeter, plainly indicates that the radiant energy was exceedingly high in the center of the area covered at a distance of 5 inches from the end of the bulb but decreased rapidly outside of this area. The area within the radius of an inch from the center gave

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from 50 to 57 micro-watts per square centimeter. This was the approximate area in which the insects were exposed. The energy was measured by means of a vacuum thermocouple. In all, except six tests indicated in table 1, the infrared lamp was preheated for 15 seconds before exposing the insects to its rays.

Four different filters were used. *Corning Filter No. 255*, known as sextant red, transmits a small amount of visible red,

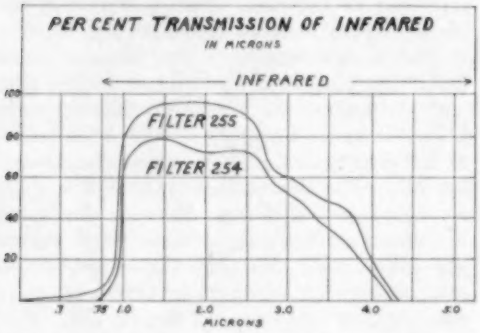

FIG. 2.—Per cent transmission of infrared filters.

some ultra violet and more than 90 per cent of infrared rays between 1 and 4 microns. This proved the most satisfactory filter for our purpose. *Corning Filter No. 254*, known as a heat transmitting filter, is opaque to the visible rays but transmits only 80 per cent infrared rays between 1 and 4 microns. A few tests were made with a *Pyrex Filter No. 246*, known as light house red, in combination with *Pyrex Filter No. 585*, known as blue purple ultra, and a water cell. This combination gives a narrow band of infrared rays just outside the visible region. No insects were killed with this combination of filters even at 2-minute exposures and at a distance of 5 inches.

After the insects were exposed to the infrared rays, a satisfactory period of time was allowed before the insects were declared dead. In the case of the confused flour beetles a period of 15 hours intervened between the time of treatment and the time of making counts. In the cases of other larvae and adults a period of 24 hours was allowed. Morbid insects at the end of this period were considered alive. Counts were made of milkweed bug eggs 14 days after treatment.

The internal temperatures of the in-

Table 1.—Effects of infrared radiation upon certain insects. Infrared lamp used at a distance of 5 inches except where noted.

NUMBER INSECTS	FILTER	EXPOSURE (SECONDS)	PER CENT KILLED
	Tribolium confusum adults		
40[1]	none	30–240[6]	0
30[1]	#255	15–60[6]	0
10[1,2]	#255	30[7]	10
10[1,2]	#255	60[7]	100
50[1,3]	none	15–300	0
30[2]	#255	15	46
10[1,2]	#255	30	90
10	#255	30	100
10	#254	15	60
10	#254	30	100
40	#246–585	15–120	0
50	#255	30	94
30	#255	30–60	0[4]
	Tribolium confusum larvae		
10	#255	15	60
20	#255	30–45	100
	Acanthoscelides obtectus adults		
10	#255	30	100
	Attagenus piceus adults		
10	#255	30	100
	Tenebrio molitor larvae		
8	none	12–13	25
4	none	14	100
4	#255	5	0
4	#255	10	0
6	#255	11	0
12	#255	12	8
22	#255	13	72
14	#255	14–30	100
8	#255	15	12[5]
8	#255	16	25[5]
4	#255	17	25[5]
4	#255	18	100[5]
	Tenebrio molitor adults; dorsal side		
2	#255	5	0
3	#255	6	33
5	#255	7	80
5	#255	8	80
2	#255	9	100
6	#255	10–30	100
	Tenebrio molitor adults; ventral side		
2	#255	5	50
3	#255	6	0
5	#255	7	20
5	#255	8	20
2	#255	9	100
6	#255	10–30	100
	Oncopeltus fasciatus eggs		
197	#255	8	35
210	#255	10	49
235	#255	12	83
190	#255	14	89

[1] No 15-second preheating period.
[2] Amber bulb used in tests.
[3] Tungsten lamp used.
[4] Specimens covered with a quarter inch of wheat flour.
[5] Filter 1 inch above surface of petri dish.
[6] Distance 21.5 in. [7] Distance 11 in.

sects were determined by means of thermocouples made with No. 30 copper-constantan enameled wires. The junction of the thermocouple was inserted between the sixth and seventh abdominal segments of the larva and forced about a half inch into the insect. It was inserted into the ventral surface of the abdomen of the adults between the fourth and fifth segments and forced into the insects for about a half inch.

Very little difficulty was experienced in exposing most of the insects to infrared rays. However, the adults of *Tenebrio molitor* immediately turned upon their backs when exposed to the rays. In order to get a few readings to show the effect of the infrared rays on the dorsal surface of these beetles, they were fastened to small pieces of glass by means of narrow strips of transparent cellulose tape.

RESULTS.—Thirty seconds at a distance of 5 inches was the minimum exposure required to kill the larvae and adults of the confused flour beetle *Tribolium confusum* with infrared rays. There seemed to be little difference between the resistance of the larvae and the adults. At 15 seconds and a distance of 5 inches, both showed 60 per cent dead.

In the case of the mealworms, there was a well marked difference between the resistance of the larvae and the adults, the larvae required 14 seconds at 5 inches while the adults were killed in 8 to 9 seconds at the same distance. Two factors may explain this difference, (1) the darker color of the adults which probably absorbed the heat energy at a greater rate and (2) the more heavily sclerotized body wall of the adults which retained the absorbed energy. There has been some work on the subject of absorption of infrared rays as a means of regulating body temperature in insects. Kruger (1929) found that the integument of the body of *Parnassius apollo* absorbed the infrared rays from the sun almost wholly while the wings reflected a considerable percentage. Buxton (1924) in studying the body temperature of the two color forms of the grasshopper *Krispa colesyrensis* found that when they were exposed to the sun the darker forms became 4 to 5 degrees hotter than the lighter forms. Headlee & Jobbins (1938) found that 30.9 per cent infrared energy penetrated both of the fore wings and 2.40 per cent penetrated all wings plus the dorsal integument of the American cockroach at a distance of 10 or 12 inches from the source of the energy. They also found that 0.14 to 0.83 per cent infrared energy penetrated 0.03 inch of various wheat products.

It appears that death as a result of exposure to infrared radiation is due to increased internal body temperature. Table 2 indicates a marked increase in the internal temperature of the insects exposed to infrared rays for the minimum period necessary to produce death. In all cases the internal temperature at the end of this period approached the average fatal temperature which, according to Uvarov (1931), is 50° C. Wigglesworth (1940) gives the fatal temperature for mealworm larvae as 42° C., for small specimens and 43° C. for specimens weighing 100 grams or more. Both table 2 and chart 3 show that adult *Tenebrio molitor* were killed at a lower temperature than the larvae. It should be noted that the internal temperature of the adults rose slightly after the infrared lamp was turned off, again indicating the effect of their greater rate of heat absorption due to their darker color. Also the internal temperature of the adults fell off slowly. In the case of the larvae the highest temperature was reached at the time the infrared lamp was turned off and the internal temperature fell off rapidly. In the graphs of two sets of larvae, Chart 3, four larvae were exposed in a closed chamber, i.e., with the filter on top of the petri dish and five larvae were exposed in an open chamber, i.e. with the filter one inch above the petri dish. The differences in body temperature at the end of the exposure, the lethal time, is attributed to experimental error for it is

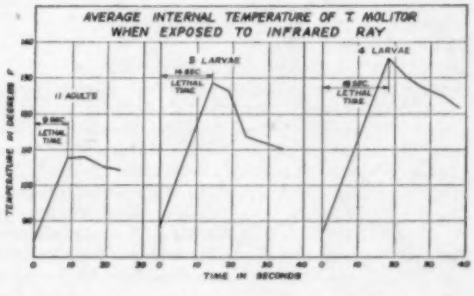

FIG. 3.—Average internal temperature of *T. molitor* when exposed to infrared.

Table 2.—Internal temperatures of mealworms at lethal exposures.[1]

NUMBER OF SPECIMENS	DURATION OF EXPOSURE	TEMP. BEFORE EXPOSURE	TEMP. AT END OF EXPOSURE
8 larvae	14 sec.	32.9°C	52.5°C
4 larvae	18[2]	31.5	57.6
11 adults[3]	9	29.1	44.9

[1] All tests were conducted at a distance of 5 inches from the infrared lamp.
[2] The filter in this test was placed one inch above the petri dish containing the insects treated. In the other tests the filter was placed directly on top of the petri dish.
[3] The ventral surfaces of the adults were exposed to the infrared rays.

believed that the internal temperatures would be approximately the same.

The possibility of using infrared radiation for insect control was first suggested by Blazer (1942). He figured a battery of infrared lamps for treating rice to control injurious species. Cotton (1941) states that 60° C. for 10 minutes is fatal to all grain insects. A temperature of 82.2° C. is considered the maximum safe temperature for drying wheat without injury to milling and baking qualities. A few preliminary tests with infrared radiation showed that no kill was obtained when confused flour beetles were covered with a quarter of an inch of wheat flour. Thirty beetles were exposed under these conditions for 1 minute at a distance of 5 inches but all the beetles were alive at the end of the test. There is no doubt that sufficiently high temperatures can be induced in grain insects by means of infrared radiation to produce death. The solution of the problem lies in finding a satisfactory means of treating infested grain.—2-21-44.

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JOHN RAYMOND HORTON

John Raymond Horton, Entomologist in the, U. S. Bureau of Entomology and Plant Quarantine, since 1909, died at Wichita, Kansas on April 7th, age 61 years. During his period of service he was employed in the investigation of citrus and fig insects and those affecting cereal and forage crops. He was an industrious and extremely conscientious worker.—C. M. PACKARD.

CHARLES S. BECKWITH

Charles S. Beckwith, Secretary of the Eastern Branch of the Association died suddenly on May 18, while actively at work in a cranberry bog near Pemberton, New Jersey.

Mr. Beckwith was a graduate of Rutgers University, and has been for many years a member of the Association.

SCIENTIFIC NOTES

Results of Tests with Domestic Animals Confined on Pastures Sprayed with Natural Cryolite

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During the season of 1943 cryolite was substituted for lead arsenate in the Federal spraying programs for the control of the gypsy moth and the white-fringed beetle. As there had been conflicting statements regarding the toxic effect of this chemical on domestic animals, a study was initiated and carried through during the summer of 1943 at the Animal Disease Station, Beltsville Research Center, Beltsville, Md., to obtain some specific, though preliminary, information regarding the toxicity of cryolite to domestic livestock.

The chemical used in the test was natural cryolite (Na_3AlF_6) containing not less than 90 per cent of sodium fluoaluminate, with a net content of not less than 49 per cent of fluorine. It was applied to pasture areas at the rate of 40 pounds per acre and was prepared for application by mixing 4 pounds of the dry powder in 6 gallons of water and adding 0.4 pint of linseed oil as an adhesive. This rather highly concentrated spray mixture adhered to the grass foliage very well and there was little or no run-off. Quantitative analyses[3] of hay samples taken from each plot immediately after the spraying showed that practically all the cryolite applied was deposited on the forage.

Applications were made with 3-gallon knapsack sprayers equipped with regular garden spray nozzles.

The five adjoining pastures used were fenced-in, tenth-acre paddocks, measuring 66 feet on each side, containing an estimated 2 tons of hay (dry) per acre.

The animals used were,—one healthy 16-year-old mare, one healthy 15-year-old gelding, two healthy 2-year-old pregnant heifers, and two year-old rams, apparently healthy except for a continuous but moderate nasal discharge.

The first test was begun on June 14 when the mare and one cow were turned in on a paddock freshly sprayed with 4 pounds of cryolite. Within 5 days these animals had consumed nearly all the vegetation. That which remained was coarse, strawlike, and much trampled down. The two rains that fell during the period apparently did not remove much of the spray deposit from the forage. The animals were removed from the plot on June 19 and placed on oats and dry timothy hay. They continued in good health.

Assuming that at least 50 per cent of the cryolite applied was consumed by the horse and cow and that a horse eats about three-fourths as much as a cow, then the horse took into its body approximately 0.9 pound of cryolite and the cow 1.1 pounds.

The second test feeding began on June 22 when the gelding, the second cow, and the two sheep were placed in a paddock freshly sprayed with 4 pounds of cryolite. For the 24 hours prior to the test these four animals had been deprived of feed. Consequently when put into the plot they fed heartily and after 6 days had consumed most of the forage.

On June 28 they were turned into a second paddock freshly sprayed with 4 pounds of cryolite. After 7 days this plot was nearly bare. During this 7-day period these animals had access also to the plot in which they had fed from June 22 to June 28. Two very light rains fell, one on June 29 and the other on June 30, but apparently very little spray residue was washed from the foliage.

On July 5 the gate between these two plots and a third plot freshly sprayed with 4 pounds of cryolite was opened, and the four animals began to feed in this third plot although having access also to the previously sprayed plots. This new plot was slightly larger than a tenth-acre, but only a tenth-acre portion had been sprayed, the remaining area of approximately 15 by 66 feet being left unsprayed. At first there was an indication that the horse preferred the unsprayed portion, but within 7 days all the forage, sprayed and unsprayed, had been consumed. Extremely light rains fell each night of this period with no apparent effect on the spray residue.

On July 12 one-half of another tenth-acre plot was sprayed with 2 pounds of cryolite and was also opened to the animals. The animals showed no immediate or later evidence of preference for either the sprayed or unsprayed forage, but within 7 days they consumed practically all the feed. The rainfall after this last spraying was insignificant.

On July 19 the four animals were removed from the plots and placed on dry feed with the other two animals. All the animals appeared healthy and continued so with the exception of one sheep. This sheep had first appeared thin and listless on July 17.

Again assuming (1) that 50 per cent of the cryolite applied was eaten by the animals, (2) that feeding by the horse and cow was in the proportions already mentioned, and (3) that each sheep ate one-fourth as much as each cow, then between June 22 and July 19 the horse ingested 2.3 pounds of cryolite, the cow 3.1 pounds, and each sheep 0.8 pound.

The thin and listless sheep picked up in weight and appearance after being on dry feed for several weeks. On August 14 it was killed and examined. There were not enough parasites present to have caused any noticeable effect on the animal,[4] histopathological examinations of the vital organs failed to reveal significant pathological alterations,[5] and the cause of its poor condition was not determined.

On August 25 the other sheep was given orally 8 ounces of cryolite in 2 quarts of water. Six days later it was given a pound of cryolite in 2 quarts of water. In spite of these feedings the sheep continued in apparent good health and its appetite was not affected.

In conclusion it can be stated that residues on forage sprayed with cryolite at the rate of 40 pounds per acre were not found to be injurious to domestic animals feeding on the forage under the conditions of these experiments.—12-27-43.

[1] Of the Bureau of Entomology and Plant Quarantine.

[2] Of the Bureau of Animal Industry.

[3] Fluorine determinations on this study were made by R. H. Carter, Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine.

[4] The internal parasite examination was made by Gerard Dikmans, Zoological Division, Bureau of Animal Industry.

[5] The histopathological examinations were made by Herman R. Siebold, Pathological Division, Bureau of Animal Industry.

Control of the Common Red Spider[1]

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The first material which was used for the control of the common red spider *Tetranychus telarius* on the alfalfa plants in the Kansas Agricultural Experiment Station greenhouses in 1941 and 1942 was a chemical which had the trade designation *Emulsifier B-1956 Spreader*.[2] Later, work was done with another product which is considered better than *Emulsifier B-1956 Spreader* for the control of the red spider. This product, known as *DN-111*,[3] a dinitro-o-cyclohexylphenol salt, is used at the rate of a half pound to a pound to 100 gallons of water. Neither of these dilutions burned the alfalfa, wheat, oats, barley, corn or sorghum plants, and appeared to give practically the same control. It later was demonstrated that *DN-111*, at the half-pound rate, controlled this mite on peach and lima beans without injury to the foliage. This material at the 1 pound to 100 gallons rate, in small quantities, is used at the rate of 0.112 gram to 100 cc., or 1 teaspoonful to 1 gallon of water. Only one application of an insecticide was made to any plant.

Since *DN-111* has not been used extensively and, in the stronger concentration, it may burn plant foliage, it is suggested to use the half-pound rate, or even less, The use of *DN-111* at the half- or one third-pound rate will give more effective control than *Emulsifier B-1956 Spreader* or in combinations with *RS-380*.[4] When *DN-111* was used at the half-pound rate, effective control of the eggs and mites was brought about within four days.

The *Emulsifier B-1956 Spreader*, for the control of the common red spider was first used by Ark & Tompkins (1941). When a 2 per cent solution of the *Emulsifier B-1956 Spreader* was used in 1941, one application of the spray gave fairly good control of the red spider, and no viable eggs or adults were found after a period of 12 days. In later experimental work it was found that a mixture of *Emulsifier B-1956 Spreader* at the rate of 1 to 400, with *RS-380* at the rate of 1 to 200, gave effective control of these pests in 4 to 6 days.

The common red spider infests both sides of leaves. In spraying for effective control, all parts of the plant and both sides of the leaves should be thoroughly wet with the spray. Apply the spray to the point of dripping, but avoid dripping. Where leaves have a heavy pubescence, it is necessary that more spray pressure be exerted for proper penetration.

It is recommended that, for the best protection of greenhouse plants against the attack of the common red spider, the insecticide be applied at regular intervals, or every 4 to 6 weeks. This procedure has proved to be an excellent method of preventing the common red spider from becoming a serious pest on green-house-grown experimental plants.—2-18-44.

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[1] Contribution No. 530 from the Department of Entomology.
[2] Manufactured by Rohm & Haas, Philadelphia, Pa.
[3] Manufactured by the Dow Chemical Co., Midland, Mich.
[4] An insecticide, with spreader, made by Rohm & Haas, Philadelphia, Pa.

Lethane 384 Special for Control of the Brown Dog Tick

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The difficult problem of ridding domestic pets and buildings of this pest has been intensified by the necessary wartime restrictions on the use of rotenone (and pyrethrum) for this purpose. Although certain arsenicals have been recommended, they should not be considered to be safe for the average householder.

The necessity recently arose of giving advice in connection with a heavy infestation of the brown dog tick, *Rhipicephalus sanguineus* Latr., on dogs and in a house. The experiments conducted were purely empirical due to lack of proper equipment for handling ticks and to failure of the owner to cooperate.

A dust was prepared containing the following:

Lethane 384 Special[1]	5 grams.
$MgCO_3$	2 grams.
Pyrax ABB	100 grams.

This dust was left with the owner with instructions for applying it, but these were not carried out, consequently no information could be obtained as to its effect on the ticks *in situ*. However, a number of ticks were taken from the dogs and from the whelping pen and were treated in the laboratory. These were placed in a metal box with a small quantity of the powder, and the box was shaken gently until the ticks were more or less uniformly dusted. The ticks were in the following developmental stages: 10 unfed larvae; 2 engorged nymphs; 4 adult males; 3 adult females, unengorged; 1 adult female, slightly engorged; 1 adult female, about three fourths engorged; 2 adult ovipositing females.

All of the ticks were visibly affected within half an hour and at the end of an hour the unengorged males and females appeared to be dead. After 24 hours only the two engorged nymphs were alive. These latter were still alive after 5 days, one quite active, the other somewhat sluggish although still able to crawl. The excess dust from the first treatment was removed from the box and these two nymphs were dusted again. One was dead on the third day, the other on the fifth day following the second dusting.

Although the excess dust was removed from the box following the second treatment, there is a chance, as in the first case, that fumigant-action may have been involved (Busvine 1943). Since only a very small amount was involved, however, this does not seem likely. Ten unfed larvae which hatched from eggs collected in the pen were similarly dusted with the same material but the excess was removed and they were kept in an open container. All were affected within a few minutes, and after 2 hours only a slight twitching of the legs was evident. At the end of 6 hours all larvae were apparently dead. The various specimens used in these trials were held under observation for several days after apparent death, and none revived. The action of this insecticide appears to be in part a progressive paralysis of the legs; the posterior pair is affected first, then successively the second and first pair.

Dusts including, respectively, 5 per cent tetraethyl thiuram disulfide, and 10 per cent tetramethyl thiuram disulfide were tested on unfed larvae, but neither was effective at the concentrations used.

[1] A combination of n-butyl carbitol thiocyanate and beta-thiocyano ethyl esters of higher fatty acids.

It is hoped that further and more precise experiments will be carried out with these materials in a laboratory equipped to rear ticks. In this case the age of none of the specimens was known, nor, in most cases, the extent to which they had fed. Further, some of the ticks may have been injured in removing them from the dogs, although care was taken to avoid this as far as possible. However, it does appear that *Lethane 384 Special* may be effectively used to control the brown dog tick and probably other species as well. Engorged nymphs are difficult to kill in any case, and may need repeated treatment. Furthermore, *Lethane 384 Special* should be innocuous to animals and to man at concentrations tested.—1-10-44.

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Insecticidal Possibilities of *Duboisia hopwoodii*

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The long-standing uncertainty as to the alkaloid present in *Duboisia hopwoodii* was settled by the work of Hicks & Le Messurier (1935) and Späth *et al.* (1935), when they proved the presence of nornicotine. Analyses showing the alkaloid content, however, have not come to the attention of the writer. Hicks while not giving his final yield of pure alkaloid, quoted a total volume of crude product before fractionation which indicates an alkaloid content of about 1 per cent.

A shipment of 17 pounds of *Duboisia hopwoodii* from Australia recently received at this laboratory was so subdivided that samples of leaves, leaves on twigs, twigs without leaves, and larger stems were obtained. The ground dry leaves were steam-distilled with sodium chloride and sodium hydroxide, and the distillate was tested for nornicotine according to the procedure used on tobacco by Bowen & Barthel (1944). The picrate of the steam-volatile alkaloids had a melting point of 191–192° C. (cor.), while the picrate of the methylated steam-volatile alkaloids melted at 223.5–224° C. (cor.), thus confirming the presence of nornicotine. The quantitative analysis for nicotine and nornicotine by the method of Bowen & Barthel (1943) used for tobacco showed only nornicotine present—3.31 per cent in leaves, 1.92 per cent in leaves on twigs, 0.95 per cent in twigs without leaves, and 0.52 per cent in the larger stems. No alkaloids were present in the distillation residue; consequently nornicotine was the only alkaloid present in the plant material investigated.

The reports of Richardson *et al.* (1936) and Hansberry & Norton (1940) that all the nornicotines seem more toxic than natural nicotine to *Aphis rumicis* L. indicate that a wild plant material having an alkaloid content such as this lot of *Duboisia hopwoodii* should be exploited as a source of insecticidal material. It is to be expected that higher alkaloida[1] content would result from pruning, fertilizing, removal of flowers, and other cultivation practices.—1-31-44.

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Control of the Vegetable Weevil in Tobacco Plant Beds

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The vegetable weevil, *Listroderes obliquus* Klug, first found feeding on tobacco in Gadsden County, Fla., in 1937 (Chamberlin & Madden 1937) has become of great importance among the insect pests infesting tobacco plant beds in the Florida-Georgia cigar-tobacco-producing area. Observations have shown that in the absence of control measures the larvae of this insect may cause serious damage to the seedlings and may be carried on infested plants to the field, with resulting detriment to the stand.

Preliminary experiments carried out in 1938 and 1939 at Quincy, Fla., indicated that vegetable weevil larvae in tobacco plant beds maybe controlled readily with lead arsenate, but tests with materials containing rotenone gave much less satisfactory results.

The results of control experiments carried out on infested tobacco plant beds during the period 1940 to 1943 are shown in table 1. The materials were applied to plots 3 by 3 feet in size, with four to eight replications of each treatment. The treatments were evaluated when the seedlings had attained transplanting size. The method consisted in removing the plants from three areas, 1 square foot in size, taken at random in each of the plots, examining the plants for weevil injury, and counting the live larvae present on the plants and in the top soil of the sampled areas. Although evidence of slight weevil feeding was observed on many of the seedlings, only the seriously damaged plants were recorded.

The results of experiments conducted by the author, and of observations on commercial spraying and dusting, show that the insect may be controlled

Table 1.—The effectiveness of various insecticidal treatments in the control of vegetable weevil larvae on tobacco seedlings, 1939–43.

Treatments	Plants		Weevils Found	Remarks
	Examined	Injured by Weevils		
	Number	*Per Cent*	*Number*	
1940, 3 Applications:				
Lead arsenate spray (1.5 lbs. per 100 gal.)	422	0.5	0	Good control.
Lead arsenate spray (3 lbs. per 100 gal.)	521	.4	0	Good control.
Lead arsenate spray (6 lbs. per 100 gal.)	573	.5	0	Good control. Some leaf injury.
No treatment	466	29.6	25	
1941, 3 Applications:				
Lead arsenate spray (1.5 lbs. per 100 gal.)	497	6.0	62	Numerous small larvae which might be carried on the plants to the fields.
Lead arsenate spray (3 lbs. per 100 gal.)	465	6.7	29	Control fair. An additional application indicated.
Lead arsenate spray (6 lbs. per 100 gal.)	467	3.6	21	Fair control. Slight burning.
No treatment	416	73.8	299	
1942, 4 Applications:				
Lead arsenate spray (3 lbs. per 100 gal.)	325	1.5	4	Satisfactory.
Lead arsenate and tobacco dust (50–50)	359	2.8	0	Satisfactory.
Synthetic cryolite and tobacco dust (8–2)	298	1.0	0	Satisfactory.
No treatment	391	54.7	65	
1943, 4 Applications:				
Lead arsenate spray (2 lbs. per 100 gal.)	199	1.5	0	Satisfactory.
Lead arsenate spray (3 lbs. per 100 gal.)	218	0	0	Satisfactory.
Lead arsenate and tobacco dust (50–50)	183	0	0	Satisfactory.
Lead arsenate spray (3 lbs. per 100 gal.) and ferric dimethyl dithiocarbamate (1.5 lbs. per 100 gal.)	244	1.2	0	Satisfactory. No foliage burning.
Lead arsenate, ferric dimethyl dithiocarbamate and tobacco dust (2.5–1–1.5)	224	.4	0	Satisfactory. No foliage burning.
No treatment	256	64.1	28	

satisfactorily in the tobacco plant beds in the Florida-Georgia cigar-tobacco-producing area with lead arsenate, applied as either a spray or a dust. In the spray form lead arsenate should be prepared at the rate of 2 to 3 pounds per 100 gallons of water and applied at the rate of approximately 3 gallons of the spray to 100 square yards of plant bed. When applied to the beds in the form of a dust it should be mixed with equal parts, by weight, of a finely ground, sterilized tobacco dust or other suitable carrier, to insure even distribution, and should be applied at the rate of 8 ounces of the dust mixture to 100 square yards of plant bed. From three to four applications are required to control relatively heavy infestations in the plant bed and should be made about a week apart during the latter part of the growing season. One or two applications of the arsenical are usually sufficient to control light infestations of the weevil.

Tobacco plant beds in the Florida-Georgia area are frequently treated with fungicides to control the blue mold (downy mildew) disease, *Peronospora tabacina* Adam, and it is often advantageous to include the arsenical with these treatments. Experiments and commercial practices indicate that lead arsenate may be safely incorporated in sprays for blue mold, containing copper oxide, vegetable oils, and a proprietary phthalic glycerol alkyl resin spreader. Combination sprays and dusts containing a commercialy prepared ferric dimethyl dithiocarbamate and the arsenical may also be applied to the seedlings with apparent safety.—2-12-44.

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A Simplified Method of Sampling Known Areas of Apple Leaves for Chemical Analysis[1]

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During this critical period, when carefully tooled instruments are difficult to obtain, it is especially important to use simplified methods that require a minimum of apparatus. The apparatus described here consists of a double template that can be made in half an hour at practically any tin shop.

[1] Eastern Branch Program, 1943.

FIG. 1.—A. Double template with the two halves fitted together. B. Placing the apple leaves on the template. C. Five apple leaves on the template, ready for cutting. D. Apple leaf sections cut, ready to remove from the template. E. Placing the leaf sections in a container which holds a sample of 100 sections.

The template consists of two pieces of flat sheet metal, octagonal in shape. The size should be determined by the size of the leaves to be cut. One of the metal pieces, the template proper, is larger than the other, so as to extend beyond the smaller piece approximately 1.5 mm. on all sides. With the two pieces fitted together properly, and firmly clamped, two small holes are bored through both pieces. The holes should be just large enough to allow easy passage of the pin of a large thumbtack. Each hole should be on the longitudinal median line of the template, and about half way from the middle to the end of the line. With the points of the thumbtacks extending through the holes in both templates, the heads of the tacks are soldered to the back of the larger template. A small handle, soldered to the back of each template, completes the apparatus (Fig. 1A).

In use, the larger template was held with the pins up (Fig. 1B). A leaf was picked from the tree, and firmly impaled on the pins, so that the margins of the leaf extended beyond the limits of the template on all sides. Another leaf was placed over the first, a third over the second, and so on, until five leaves were fixed on the template. In each case care was used to insure that each leaf fully covered the template. It was found that five leaves could be cut readily at one time, and all samples were made by cutting five at a time.

When the five leaves were in position on the larger template, with the pins extending upward through all of the leaves, the smaller template was placed in position carefully, so as to reduce the danger of removing spray deposit from the leaves, and pressed down firmly over the leaves, with the pins of the larger template extending through the holes of the smaller. Holding the larger template uppermost, the leaves were trimmed with ordinary shears (Fig. 1C). The leaf sections were then removed from the template, and placed in a container for preservation until the chemical analysis could be made (Fig. 1, D, E).

It was not assumed that all of the leaf sections were the same size as the template on which they were cut. To ascertain the areas, 100 of the leaf sections were measured by means of a planimeter. Two such double templates were constructed for cutting leaves of different sizes. The mean areas (in square centimeters) of 100 sections from each of the templates were found to be $12.61 \pm .0194$ and $18.66 \pm .0166$. Each sample for analysis consisted of 100 leaf sections. The total leaf area in each sample from the two templates used was, therefore, 1261 sq. cm. and 1866 sq. cm., respectively. The probable errors indicate that the variations from the mean areas were small, and the samples were statistically reliable. The leaf areas in each 100-section sample were large enough so that, for ordinary spray deposits, the analysis for arsenic could be made by the bromate method.[1] The method of sampling described here is much more rapid than the punches sometimes used, and the comparatively large size of the samples collected by the template method probably increases the accuracy of the results.

In collecting and cutting the samples certain precautions were taken in an effort to increase the accuracy of the results. In handling the leaves, care was taken to avoid touching the portion of the leaf to be included in the sample. The sections were removed from the template, and placed in the container, by means of forceps. Five leaves were cut at each time. Each time, the cuts were made as nearly alike as practicable. Reasonably flat leaves were used for the samples, and decidedly curled or rolled leaves were avoided.

The templates described here have been used during a period of three years for studies of arsenical deposit on apple foliage by the Maine Agricultural Experiment Station. The results appear to be entirely satisfactory.—11-29-43.

[1] Official and Tentative Methods of Analysis of the Association of Official Agr. Chemists, 5th Edition, 1940. pp. 393–4.

Mineral Oils as Diluents of the Geraniol-Eugenol Japanese Beetle Bait[1]

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Recent studies at the University of Maryland have had as their objective, improvement of Japanese beetle bait. Data collected indicate that an effective bait may be obtained by diluting the present geraniol-eugenol mixture with white mineral oils.

The present generally recommended bait which consists of a mixture of ten parts of geraniol and one part of eugenol has been developed by various workers in the United States Department of Agriculture. Richmond (1927) in experiments on the olfactory response of the beetle, arrived at the conclusion that geraniol was a primary attractant but that its attractiveness was enhanced by the addition of eugenol. Early baits contained bran as a carrier for these attractants. In 1933 Metzger proposed their use at the present ratio in a liquid concentrate.

Metzger & Maines (1935) pointed out that technical geraniol, because of certain attractive impurities, was more efficient than the previously recommended pure material. An increase in the attractiveness of the bait by changing the geraniol-eugenol mixture to a ten to eight proportion was demonstrated by Fleming and Burgess (1940). They pointed out, however, the great increase in cost of such a bait. Langford *et al.* (1943) indicated the possibility of diluting known attractants without materially affecting the efficiency of the mixture.

METHODS.—The diluent used in this experiment consisted of a mixture of 50 parts of light white mineral oil (Saybolt viscosity 125 to 135) and fifty parts of diobase oil. This proportion was selected from a series of mixtures as it closely approached the evaporation rate of the geraniol and eugenol bait. Evaporation rates were determined by evaporating measured and weighed liquids from one-half inch cotton wicks and the free surface of two ounce bait bottles.

The selected diluent was then combined in field tests in various proportions with a mixture of nine parts of geraniol and one part of eugenol. This ratio of geraniol-eugenol was used in place of the usual ratio as it facilitated rapid measurements in small quantities. For the purposes of this study this ratio has been designated as the standard. In the field tests thirty cubic centimeters of the diluted and undiluted baits were placed in two ounce bottles and allowed to evaporate through half-inch cotton wicks. Baits were replenished when no liquid other than that contained in the wick was visible. Traps were arranged in linear batteries with at least one standard for every fourth trap. Each battery also contained an empty trap. Beetle counts and trap rotations were made daily, the latter in an attempt to overcome the effects of trap location and possible masking by adjacent traps. Each bait was replicated four times.

RESULTS.—Data obtained with a series of diluted baits (Test 1), containing from one to nine parts of the diluent showed that diluted baits exhibited a progressive increase in catch from the more dilute to the less dilute mixtures. This increase in attractiveness, although apparent and significant, was not proportionate to the amount of diluent used. The attractiveness of the baits increased from an average of 5829 beetles for the mixture which contained nine parts of the diluent to 12,128 beetles for that containing four parts of diluent. Above this ratio the baits varied slightly in total catches but remained well within the variation range of the undiluted bait.

It was found that the standard or undiluted bait varied considerably in attractiveness. Averages of four comparable traps in the four batteries used gave a high seasonal catch for the standard of 13,137 beetles and a low of 11,829. Variation of the standard which was attributable to location also occurred between batteries.

A mixture composed of five parts of diluent and five parts of the standard seemed to make an effective bait. It averaged 11,497 beetles as compared with 11,829 for the lowest standard. This effectiveness was substantiated by a late season test (Test 2), composed of eight traps, four of the standard and four of the diluted bait. The diluted bait in this test caught an average of 233 beetles as compared with 226 for the standard.

In noting the fact that the decrease in beetle catch was not proportionate to the increase of dilution it should be pointed out that the mineral oils used as diluents were slightly attractive. However, as the empty traps averaged 431 beetles as compared with 679 for the diluent, it was apparent that no great increase in attractiveness could be attributed to the diluents.

CONCLUSION.—Studies on the dilution of the geraniol-eugenol Japanese beetle bait indicate that an effective bait may be obtained by diluting the so-

Table 1.—Results, Season of 1943, College Park, Maryland.

BAIT	SEASONAL BEETLE CATCH				
	Battery 1	Battery 2	Battery 3	Battery 4	Average
TEST NUMBER 1 (OPERATED 49 DAYS)					
Diluent and Standard 9-1	7,449	7,704	4,750	3,416	5,829
Diluent and Standard 8-2	10,102	6,990	4,859	5,180	6,782
Diluent and Standard 7-3	11,293	8,130	5,306	5,952	7,680
Standard	18,173	14,322	7,338	9,041	12,213
Diluent and Standard 6-4	13,744	14,769	6,643	7,635	10,697
Diluent and Standard 5-5	12,871	13,226	7,937	11,955	11,497
Diluent and Standard 4-6	15,835	15,848	7,080	9,752	12,128
Standard	13,693	14,063	8,691	10,069	11,829
Diluent and Standard 3-7	12,369	17,277	9,617	9,903	12,291
Diluent and Standard 2-8	10,919	16,291	8,866	11,202	11,819
Diluent and Standard 1-9	12,221	16,585	8,871	12,990	12,666
Standard	13,209	16,795	9,960	16,584	14,137
Diluent	449	490	1,255	522	679
Empty Trap	417	444	466	399	431
Standard	14,553	14,451	7,878	11,375	12,062
TEST NUMBER 2 (OPERATED 14 DAYS)					
Standard	249	218	220	219	226
Diluent and Standard 5-5	260	222	215	236	233

called standard bait with a mixture of equal parts of white mineral and deobase oil. A 50 per cent concentration appears to be near the maximum dilution for an efficient bait. This dilution of the present bait substantially reduces the cost of operating traps. — 11-29-43.

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[1] Eastern Branch Program, 1943.

Gynandromorphism in Recently Collected Mosquitoes

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The biological phenomenon of gynandromorphism generally occurs very rarely amongst most groups of insects and according to Marshall (1938) it is even more unusual amongst mosquitoes than is generally supposed. To justify this statement he further points out that in the last twenty years only seven cases of aberration of this kind have been recorded from England.

The Fourth Service Command Medical Laboratory, Department of Entomology has examined and identified over 745,000 adult mosquitoes in the last two years and to date (November 1943) we have encountered but three of these gynandromorphs. Unfortunately, one of these specimens has been lost, but the remaining two are now deposited in the collection of the United States National Museum.

SPECIMEN A. (Fig. 1.)—Gynandromorph of *Culex pipiensquinquefasciatus*, Camp Tyson, Paris, Henry County, Tenn. September 1, 1943. Right antenna, right palpus (apical segment broken off), right fore and left mid tarsi as in male, normal. Left antenna as in female but with some unusually long hairs; left palpus short as in female but distorted apically; left fore tarsus broken; right midtarsus as in female, normal. Genitalia female, normal, with spermathecae. The abdomen of this specimen was severed before it was recognized as an aberrant. All parts of the original specimen are present in the slide however.

SPECIMEN B. (Fig. 2.)—Gynandromorph of *Culex*

Captain, Sanitary Corps, AUS.

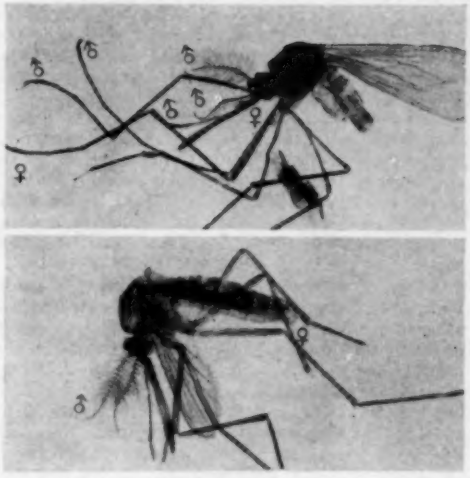

FIG. 1.—Above—Specimen A; Below—Specimen B.

quinquefasciatus, Camp Gordon, Augusta, Richmond County, Georgia, August 15, 1943. Antennae and palpi as in male, normal. All tarsi are broken off. Genitalia as in female, spermathecae not visible.—11-27-43.

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Dichloropropane-Dichloropropylene, A New Soil Fumigant for Wireworms

M. W. STONE, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

A new soil fumigant, not yet on the general market, consisting of a mixture of 1–2 dichloropropane and 1–3 dichloropropylene[1] which has been reported as giving a very real measure of control of the root knot nematode of vegetable crops (Carter, 1943) has proved to be toxic to the larvae of the sugar-beet wireworm, *Limonius californicus* (Mann.), in a small series of laboratory and field tests conducted at Ventura, Calif.

In preliminary tests with wireworms in 8-inch pots filled with sandy loam soil, concentrations of 0.25, 0.50, 0.75 and 1 cc. of this material per gallon of water, applied at the rate of 1 quart of solution per pot, killed 40, 93.1, 98.3, and 98.2 per cent, respectively, of the wireworms within 5 days. To determine the progressive mortality, a second series of 8-inch pots filled with sandy loam soil containing wireworms were each treated with 1 quart of solution containing 1 cc. of the dichloropropane-dichloropropylene mixture per gallon of water. In these tests, wireworm mortalities of 38.9, 66.2, 80.8, 91.1, and 96.7 per cent were obtained after 16, 24, 36, 48, and 72 hours, respectively, as compared with an

[1] The material used in these tests contained, by volume, 96 per cent of the crude dichloropropane-dichloropropylene mixture and 4 per cent of an oil-soluble emulsifier. It was furnished by the Shell Oil Company, San Francisco, Calif.

average 2.5 per cent mortality of wireworms in the control pots. The number of wireworms per pot ranged from 55 to 59 in the first series of tests and from 54 to 80 in the second series. The moisture content of the soil used in the pots of both series of tests ranged from 12 to 14 per cent, by weight, before treatment. Soil temperatures in the treated pots ranged from 58° to 74° F. in the first series of tests and from 42° to 66° in the second series. Two- and three-year-old wireworms, ranging in length from one-half to three-fourths of an inch, were used in these tests and in all the cage tests reported in this paper.

Rows of cull beans planted in a trench of sandy loam soil to attract wireworms were treated with a 1.5-cc. concentration of the dichloropropane-dichloropropylene mixture per gallon of water at the rate of 1 gallon of solution per foot of row. Siftings of 6 soil samples, 4 inches deep, 4 inches wide, and 3 feet long, taken in the row 4 days after the treatment showed that 95 per cent of the wireworms had been killed. An average of 1.5 wireworms (counting both the dead and living) were recovered per linear foot in the treated rows, as compared with an average of 1.6 wireworms in 12 samples taken in the row treated with water only, indicating that the material had not repelled the wireworms. A total of 26 dead and 1 living were found in the treated rows and 57 living wireworms in twice the length of row treated with water only. These wireworms were of various ages and sizes. The moisture content of the soil before treatment ranged from 12 to 16 per cent, by weight. The temperature of the soil was not determined.

To compare this material with carbon disulfide, field tests were conducted in packed, moist, sandy loam soil. In each test 29.57 cc. (1 ounce liquid measure) of the chemical was injected at a depth of 1 inch at each corner of areas ranging from 12 to 24 inches square, as indicated in the first column of table 1. In the center of each square a hole was bored in the soil to a depth of 17 inches. In this hole were buried vertically two cylindrical screen-wire cages 1 inch in diameter containing wireworms and soil. The lower cage was 12 inches high and contained 10 wireworms, while the upper cage was 4 inches high and contained 5 wireworms. By this procedure it will be noted that the wireworms were placed at soil depths ranging from 5 to 17 inches in the lower cage and from 1 to 5 inches in the upper cage. A total of 120 wireworms were used for each of the chemicals, including 15 wireworms in the untreated check area. The soil-moisture content or soil temperatures were not determined in this series of tests.

Examination of the cages 5 days after treatment showed that the dichloropropane-dichloropropylene mixture had killed 100 per cent of the wireworms within lateral distances from the chemical ranging from 8.5 to 15.5 inches and to a depth of 17 inches in the soil. In comparison, carbon disulfide gave a 100 per cent kill consistently within lateral distances from the chemical ranging only from 8.5 to 11.25 inches and consequently did not kill 100 per cent of the wireworms beyond these distances at the 1 to 5 or at the 5- to 17-inch depths in the soil.

In another field trial, cylindrical wire-screen cages, 1 inch in diameter and 12 inches long, each containing 10 wireworms and sandy loam soil, were placed horizontally in the soil at the 8-, 12-, and 16-inch depths in a plot 26 by 107 feet of plowed sandy loam, and a 1-cc. concentration of dichloropropane-dichloropropylene per gallon of water was applied with a spray rig at the rate of 1.25 gallons of solution per square foot of soil surface. A total of 9 cages were used in these tests, containing a total of 90 wireworms. Examination of these cages 5 days after treatment showed that only 30 and 32 per cent of the wireworms had been killed at the 8- and 12-inch depths, respectively, and none at the 16-inch depth. Since only a slight odor of the dichloropropane-dichloropropylene mixture was detected at the lower depths, it appeared that the 1-cc. concentration was too weak or that an insufficient quantity of solution had been applied.

Table 1.—Wireworm mortality in cages placed different distances from 4 doses of a 1-ounce application of dichloropropane-dichloropropylene or carbon disulfide. The dosages were injected at the 4 corners of square plots.

Size of Squares	Mortality of Wireworms in Cages			
	1- to 5-Inch Depth		5- to 17-Inch Depth	
	D-D[1] Mixture	Carbon Disulfide	D-D[1] Mixture	Carbon Disulfide
Inches	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
12	100	100	100	100
14	100	100	100	100
16	100	100	100	100
18	100	20	100	100
20	100	0	100	80
22	100	0	100	100
24	40	0	100	70
Check	5[2]	0	5[2]	0

[1] Dichloropropane-dichloropropylene mixture.
[2] Appeared to have been eaten by other larvae.

An adjacent plot was furrowed out and divided into 3 smaller plots, each 18 by 25 feet. A series of cages, identical with those described in the preceding test, containing 10 wireworms in each cage were placed horizontally in the soil at the 4-, 8-, 12-, and 16-inch depths at three locations in each plot. A total of 36 cages were used in these tests, containing a total of 360 wireworms. The two outside plots were treated with 1.25 and 1.5 cc. of the dichloropropane-dichloropropylene mixture per gallon of water at the rate of 2.25 and 2 gallons of solution, respectively, per square foot of soil surface, using a spray rig for this purpose. The control plot in the center received 2.1 gallons of water per square foot. The moisture content of the soil before treatment ranged from 14 to 16 per cent, by weight, in all the tests discussed in this and the preceding paragraph. The temperature of the soil was not determined in the plots where the tests were performed, but at the laboratory, approximately one-half mile distant, the soil temperatures at a depth of 4 inches ranged from 63° to 92° F. during the period when the tests were under way.

Examination of the cages in the treated plots 5 days after treatment showed only dead wireworms, whereas in the control plot only 3.3 per cent of the wireworms had died. As a further check on wireworm mortality, a series of siftings were made of 12 one-fourth-square-foot soil samples taken to a depth of 16 inches in each plot. Eight dead and no living wireworms were recovered in the plot treated with the 1.25-cc. solution, 6 dead and no living wireworms in the plot treated with the 1.5-cc., and 9 live wireworms in the control plot. These wireworms were of various ages and sizes.

To ascertain the effect of the treatment of the dichloropropane-dichloropropylene mixture on plant growth, the plots used in the above tests were plowed

and disked, and 6 days after treatment were planted to lima beans, corn, peas, yams, and tomatoes. The seedlings of lima beans, corn, and peas in the treated plots appeared above the soil surface on the same day and in approximately the same numbers as the same plants in the untreated plots, and after 12 days there was no difference in the size, appearance, or numbers of the plants in the treated and untreated plots. As judged by appearance neither the tomatoes nor the yams appear to have been affected by the treatment.—1-3-44.

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Toxicity of Natural and Synthetic Cryolites to Rats

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This paper deals with the toxicity of the well-known insecticide cryolite to rats. Cryolite, a double fluoride of aluminum and sodium, was reported to have insecticidal value against the Mexican bean beetle by Marcovitch (1924), although it was not recommended for control purposes at that time. The cryolite was mixed with lime in the early tests and Marcovitch (1924) states that "it is certain that various fluorides, aluminates, and hydroxides are formed." Recently Marcovitch and Stanley (1942) state that "cryolite reacts readily with lime, liberating soluble sodium fluoride and sodium aluminate" and therefore "should not be used with lime on plants."

Marcovitch and co-workers in a series of papers (1937 to 1942) consider cryolite to be "the ideal insecticide" since "it will not injure foliage nor result in soil poisoning" and is "incapable of causing fatalities among man regardless of the dose consumed." Our experiences in Massachusetts have demonstrated that a cryolite spray injured foliage of fruit trees. Similar observations of foliage injury have been reported on field and other crops (Strong 1940). Marcovitch, *et al.* (1937) and Marcovitch & Stanley (1938, 1942) state that cryolite is unique in that it is not fatal to rats in any dose up to 13,500 milligrams per kilogram of body weight. However, Marcovitch & Stanley (1942) report that "it is now known that in small doses cryolite is only one-half as toxic to rats as sodium fluoride" in producing chronic toxicity. A review of the papers of Marcovitch and co-workers does not reveal the number of rats used in their tests to determine the toxicity from cryolite.

The natural cryolite is made from ore, while the synthetic cryolites are made by several patented processes. Both the natural and synthetic products are advertised and available commercially and are considered to be of essentially the same chemical composition, although various brands differ somewhat in physical properties. The natural cryolite is soluble in water at the rate of one gram in 2800 cc., while the synthetic product dissolves in 1639 cc. of water (Marcovitch & Stanley 1942). *Kryocide*, containing not less than 90 per cent of sodium fluoaluminate, manufactured by the Pennsylvania Salt Manufacturing Company was the natural product used in these tests. *Alorco*, containing not less than 85 per cent of sodium fluoaluminate, manufactured by the Aluminum Company of America was the synthetic cryolite used. The sodium fluosilicate used as a check material was *Fluorex V* containing 75 per cent of the active ingredient and manufactured by the American Fluoride Corporation.

Table 1.—The acute toxic effects of natural and synthetic cryolites and sodium fluosilicate to rats when injected by mouth.

INSECTICIDE	APPROXIMATE DOSAGE MG/KG	SEX	RESULT
Synthetic cryolite	Less than 200	♂	Normal
	200	♀	Normal
	500	—	Normal
	1000	♂	Normal
	2000	—	Normal
	2000	—	Normal
Natural cryolite	25	♂	Normal
	45	♀	Normal
	100	♂	Normal
	3300	♂	Normal
	5400	♂	Normal
	16000	♀	Normal
	26500	♂	Normal
	33600	♀	Normal
Sodium fluosilicate	100	♀	Normal
	200	♀	Normal
	275	♂	[2] Killed in
	375	♀	3 hrs.
	400	♂	32 hrs.
	—[1]	—	36 hrs.

[1] Dust placed on bottom of cage.
[2] Ill 3 days; recovered.

Rats of various ages and sizes were used in our tests. The cryolite powder was mixed with water to form a thick paste and injected into the stomach by mouth with a medicine dropper through a small catheter. The rats were etherized slightly and placed on their backs to facilitate injection with the cryolite. A flat stick about three-eighths of an inch wide and one-eighth of an inch thick with a hole through which to insert the catheter was placed between the jaws of the etherized rat to hold the mouth open and to prevent it from biting or chewing the catheter. The catheter was then inserted in the hole in the stick and gently pushed into the stomach. A medicine dropper filled with the paste cryolite was inserted into the free end of the catheter and the cryolite forced into the stomach. A small amount of water was used to wash the remaining portion of cryolite in the dropper and catheter into the rat's stomach. The rats were maintained under normal conditions before and after the tests. Marcovitch *et al.* (1937) mixed the cryolite with the food of the rats so that the mixture contained 15 per cent of cryolite, which was consumed within 20 hours.

The results from our tests are shown in the table. None of the rats showed any acute injury of any nature and appeared normal in every way following the injections. The large doses of 26.5 and 33.6 grams per kilogram of body weight seemed to fill the stomachs of these rats as they appeared much distended and felt compact to the touch. The check material, sodium fluosilicate, produced illness for three days from a dose of 275 milligrams per kilogram and death in three to 32 hours from 375 to 400 milligrams per kilogram of body weight. Likewise, a rat placed in a cage with the floor covered with a heavy layer of sodium fluosilicate dust was killed in about 36 hours.

CONCLUSIONS.—Our findings regarding the toxicity of the cryolites to rats by the injection method corroborate those of Marcovitch and co-workers, who offered the cryolite to the rats in food. Both the natural and synthetic cryolites failed to produce acute toxic symptoms in rats when given by the injection method regardless of the dosage. Sodium fluosilicate is definitely toxic to rats; a product containing 75 per cent of active ingredients being fatal at about 300 milligrams per kilogram of body weight. Sodium fluosilicate dust applied to the floor of the cage killed a rat after prolonged exposure to the dust.—2-14-44.

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A Graphic Method of Indicating the Incidence of an Insect Population

M. A. YOTHERS and F. W. CARLSON, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In the course of the study of data from experiments with the scraping and banding of apple trees for the control of the codling moth,[1] the authors have used a graphic method which would be generally useful in portraying the incidence of the population of insects in different parts of a given area. "Incidence of population" as used here refers to the occurrence of population in each unit area and not to the degree of infestation.

The experiments which furnished the data for this study were carried on in 1940 and 1941 in a section of a more or less isolated 35-year-old orchard of Winesap, Delicious, Arkansas Black, and a few Jonathan and Stayman Winesap.

To determine their effectiveness the bands were removed after apple harvest and the number of captured larvae recorded for each tree. Since approximately 50 per cent of the larvae that leave the fruit are caught in the bands these figures represent only about one-half of the total number of larvae that left the fruit, but furnish fairly reliable indices to the total population.

The numbers of larvae caught in each square group of 16 trees or tree spaces were totaled together, regardless of variety, yield, infestation, size of trees, or presence or absence of trees. A single-tree or four-tree-block presentation would obviously give a more detailed picture, but one that might be more confusing and more difficult to interpret.

The number of larvae captured in each 16-tree or tree-space area is shown in figure 1. To show these

WEST

869	370	761	1593	1429	1062	1166	2379
655	319	472	683	427	549	533	1135
340	412	511	670	443	556	554	931
309	464	607	1319	517	635	659	927
128	365	530	1198	492	354	832	712
368	319	176	642	418	515	843	710
317	381	342	873	511	429	733	710
399	365	404	543	309	227	634	820
616	673	462	676	291	533	734	1102

NORTH

1940

257	331	420	383	498	637	1212	1588
122	184	302	369	213	259	539	751
253	257	323	410	238	326	436	592
161	360	245	449	229	272	487	519
132	220	252	418	220	235	703	527
62	138	157	239	284	218	424	348
92	217	163	195	213	183	261	491
230	176	300	293	216	135	290	436
110	339	298	295	272	196	365	629

NORTH

1941

FIG. 1.—Incidence of codling moth population in a scraped and banded apple orchard as shown for 2 years by the number of larvae caught in bands on trunks of the trees in square groups of 16 trees or tree spaces.

[1] This work was a part of a project on orchard sanitation conducted at the Bureau laboratory, Yakima, Wash., E. J. Newcomer in charge. C. C. Cassil, of the Divi ion of Insecticide Investigations, assisted with the photograph and with helpful suggestions.

Since this paper was written the writers' attention has been called to the following discussions of 3-dimensional presentation of data: Hansberry, Roy and Shin Foon Chiu. 1940. Presentation of Time-Dosage-Mortality Data by Three-Dimensional Graphs. JOUR. ECON. ENT. 33 (1): 139–41, and Harries, F. H. 1943. Some Effects of Alternating Temperatures and Exposure to Cold on Embryonic Development of the Beet Leafhopper. JOUR. ECON. ENT. 36 (4): 505–9.

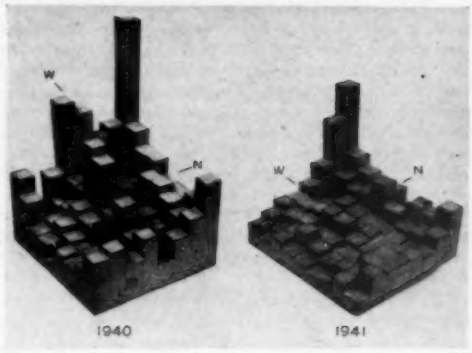

FIG. 2.—Models built to scale (100 larvae per cm. tall) illustrating the data in figure 1.

differences in population graphically a model of wooden blocks was built to scale, each centimeter of height representing 100 larvae. Each block represented a 16-tree area, and the blocks were grouped together as shown in figure 2. For example, in the 1940 model the tallest column represents 2379 larvae caught in the 16-tree block in the northwest corner of the scraped and banded block, while the shortest column represents 128 larvae caught near the center of the south tier of blocks.

The distribution of the population incidence was about the same in both seasons, although the population level was much lower the second year (24,594 as compared with 45,942). This reduction was due to a lighter crop of fruit in 1941 than in 1940 and to the effects of the scraping and banding.

The high-column area which appeared both years is next to a large pile of tree props; it is also next to a loading zone where empty boxes are stacked before distribution in the orchard, and where thousands of boxes of picked fruit and culls are stacked, sometimes for weeks, before removal from the orchard. These factors are doubtless largely responsible for the greater codling-moth population in this and nearby 16-tree areas, as shown very graphically in the models.—1-31-44.

Dusting Device for Toxicity Experiments on Field Grown Plants

E. E. IVY, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

In field-cage toxicity experiments conducted at Waco, Tex., in which the efficacy of various insecticides for control of the bollworm, *Heliothis armigera* (Hbn.), the boll weevil, *Anthonomus grandis* Boh., and the cotton leafworm, *Alabama argillacea* (Hbn.), were compared, a method of uniformly applying definite amounts of dusts to plants was needed. A dusting chamber and dusting device constructed in 1941 make possible an accurately controlled rate of application per acre with no drift. It has been found that considerabely greater uniformity of insect kill can he obtained on plants receiving the same treatment with the dusting chamber and device than is possible with hand guns. This reduces the experimental error, thereby making fewer replicates necessary.

The dusting device is constructed of half-inch copper tubing (Fig. 1.) Compressed air, supplied by an automobile tire pump enters a tapered tube through an air hose at A. A salve tin, 1, containing the weighed dust charge is held under the opening of the intake tube B. The insecticide is picked up by suction and is blown out in a dust cloud at C. D is a cork gasket, and E is a metal ring soldered inside a circular hole cut in the top of the chamber F.

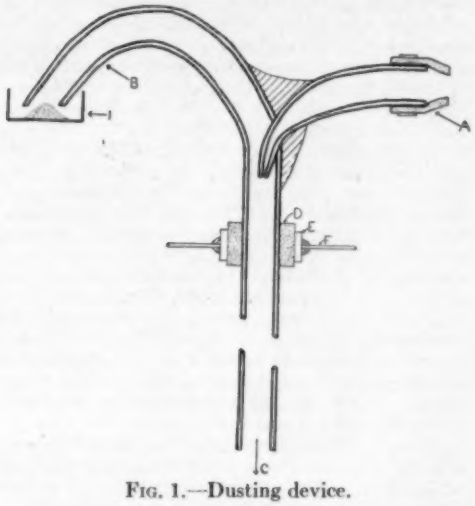

FIG. 1.—Dusting device.

The dusting chamber is made of 20 gauge galvanized sheet iron, and is 30 inches in diameter and 48 inches in height. It rests upon a galvanized sheet iron bottom plate 34 inches in diameter, which has a slot cut from its edge to the center to accommodate the plant stem. The bottom plate rests upon the cage platform.

Dosages are calculated on a per-acre basis from the area of the dusting chamber. For instance, if dust is to be applied at the rate of 8 pounds per acre, 0.41 gram of dust is required. A small quantity of dust sometimes adheres to the dusting device, but this can be dislodged by tapping the device as air is blow through it.

A very uniform dust deposit is obtained by the use of the dusting chamber and device, similar to that obtained by a good dust application by airplane. The lower leaves of the plant receive approximately as much dust as the upper ones, and some dust bounces up from the bottom plate to cover the lower surfaces of the leaves, although the lower surfaces are probably not so well covered as are the upper surfaces.

After the plant has been dusted, and the dust has been allowed sufficient time to settle, the chamber and bottom plate are removed, and a cage is placed over the plant. Cotton leaf worms or bollworms may be placed on the plant before dusting, but the more active boll weevils must be introduced into the cage after the dust has been applied.

The apparatus is light in weight and readily portable, and since a tire pump is used to furnish the air it can be used for fieldgrown plants without the necessity of laying air lines.—10-10-43.

[1] In cooperation with the Texas Agricultural Experiment Station.

"Incompatability" of Insecticides

R. C. ROARK, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Thirty years ago Gray (1914) called attention to the three types of incompatibility as applied to medicines—namely, physical, chemical, and therapeutic—and proposed that the distinctions made between them also be applied to insecticides and fungicides.

Physical incompatibility is displayed by water and mineral spray oil, because they do not mix or dissolve but remain as two separate layers. This physical repellence, or incompatibility, can be overcome by emulsifying the oil in the water by means of soap or other emulsifying agent. Many prescriptions call for physically incompatible ingredients, in which case the pharmacist labels the bottle of medicine "Shake well before using."

Chemical incompatibility results when materials are mixed that react chemically with each other. Examples are silver nitrate and hydrochloric acid, barium chloride and sulfuric acid, lime-sulfur solution and soap, nicotine sulfate and lime, nicotine sulfate and barium fluosilicate, pyrethrum extract and alkalies, and sodium chlorate and sulfur. Chemical incompatibility, unlike physical incompatibility, cannot be overcome by agitation or the addition of an emulsifier. However, the speed of a chemical reaction frequently can be retarded by the addition of a colloidal substance; for example, the reaction of lead arsenate with lime-sulfur solution is slowed down by the addition of casein.

Therapeutic, or *physiological*, incompatibility results when two or more materials having opposite or antagonistic effects upon the organism are mixed. An example is a mixture of a stimulant such as caffeine with a soporific such as barbital. In the field of entomology such antagonism is exhibited by certain fumigants when mixed. Jefferson (1943) found that a decrease in toxicity to the red flour beetle occurs when carbon tetrachloride is mixed with methyl bromide, methyl formate, or ethylene dichloride.

Horticulturists, extension workers, farmers, and insecticide salesmen have rarely observed the distinctions in the meanings of incompatibility familiar to the pharmacist and the chemist, but have employed the term "compatible" to designate mixtures that produce a desired result irrespective of physical repellence or chemical interaction. Such usage has been noted in connection with some charts issued a few years ago by one of the agricultural colleges.

One compatibility chart shows nicotine sulfate and lime as compatible materials. As a matter of fact they are incompatible chemically. When lime and nicotine sulfate are mixed, a chemical reaction takes place and free nicotine and calcium sulfate are formed. Inasmuch as free nicotine has certain physical, chemical, and insecticidal properties not possessed by nicotine sulfate, it is often preferable, or even necessary, to use free nicotine rather than nicotine sulfate, and a ready way of forming free nicotine is to mix lime and nicotine sulfate. However, it is erroneous to say that they are compatible.

Another chart correctly shows "fixed" nicotine (by which presumably nicotine bentonite is meant) as incompatible with lime. Lime and nicotine bentonite react in the same way as lime and nicotine sulfate; and one of the reaction products is free nicotine, which evaporates and is also readily soluble in water, and hence is removed from the leaves and fruit of a sprayed apple tree by rain or even on long exposure. The value of nicotine bentonite for the control of the codling moth larva is thus diminished by the addition of lime. However, lime and nicotine sulfate are just as much chemically incompatible as are lime and nicotine bentonite. Whereas nicotine in the uncombined, or free, state is more effective than nicotine sulfate as an aphicide, it must be combined in a water-insoluble form in order to remain on foliage and poison codling moth larvae. Hence the mixture of nicotine sulfate and lime is spoken of as compatible because it produces a desired result, whereas the mixture of nicotine bentonite and lime is spoken of as incompatible because it produces an *un*desired result.

A study of the several spray-compatibility charts that have been published and of some proposed for publication reveals many differences of opinion. One writer speaks of paris green and sulfur as compatible; another, as of doubtful compatibility. One chart shows nicotine sulfate solution as incompatible with calcium arsenate; the other chart states the opposite. These divergent views are due to a confusion of the three kinds of incompatibility as understood by the pharmacist, and to the writers' focusing their attention upon the control of different insects on different crops in different parts of the country. A mixture of sulfur and paris green is useful for the control of certain hemipterous insects on cotton in Arizona, but would have little value for the control of other insects on other crops in other parts of the country and would be injurious to vegetation. A writer with the first use in mind calls the mixture compatible; a writer with other uses in mind calls it incompatible.

Cox (1941) has pointed out that "compatibility" is loosely used to mean several different things. He employs it in the sense of "suitability of pest control materials for simultaneous or successive applications to the same plant." Since scientists should not employ loose terms, the writer recommends that "compatible" and "incompatible" be eliminated from the vocabulary so far as insecticides and fungicides are concerned. Instead, the terms "suitable" and "unsuitable" should be used with specific reference to the insect and host plant under consideration.

For the guidance of county agents and others called on by orchardists or truck growers for advice on mixing insecticides and fungicides, charts could be drawn up titled "Recommended Combinations of Spray Materials." Effective combinations could be connected by green lines whereas ineffective combinations, or those causing plant injury, could be indicated by red lines, as has been done in the so-called compatibility charts. These charts would have to be highly specific as to the pest to be controlled, the plant upon which the spray is to be applied, and the region where the crop is grown.—2-4-44.

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Substitutes for Creosote in Chinch Bug Barrier Construction[1]

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Since creosate came into common use in chinch bug barrier construction more than 2 decades ago its supremacy has not been successfully challenged. In fact this material has been so satisfactory that, until diversion of the creosote supply to war industries resulted in a shortage of barrier material, there seemed to be no valid reason to search for substitutes.

In preliminary experiments conducted in 1940 and 1941, a satisfactory technique for testing barriers was developed, and certain fractions of wood creosote and lignite creosote were then shown to offer promise as substitutes for coal tar creosote. In 1942, several other fractions of wood creosote were added to the series. Several old barrier materials, such as pine tar, road oil and gas drip were also included in the series to compare their efficiency with the other materials being tested.

MATERIALS AND METHODS.—Experiments conducted in 1940 and 1941 showed that the paper fence barriers were so effective and the number of bugs crossing any reasonably good material applied on paper was so small that differential values were hard to obtain. Furthermore, good paper barriers were so effective that minor physical defects such as clods and oil drops on the ground in front of the paper, wrinkles in the paper and shadows often had a greater effect on the insects' reaction than minor differences in the deterrent value of the oils being tested. All tests reported here were made against lines where the oil to be tested was applied on smooth tamped soil.

The barriers were constructed at the edge of grain fields adjoining corn where heavy natural migration was in progress. Strips 300 to 500 feet long were cultivated, smoothed and tamped to get the greatest degree of uniformity possible. Small stakes were then set at 40-inch intervals and the various oils applied between stakes so as to obtain a continuous straight line of experimental barriers each 40 inches long. The entire series of 20 oils was replicated 3 times by random selection. As a rule the construction of each new set of barriers was completed about noon so that readings could be taken 2, 6, and 24 hours after the barrier was constructed. In experiment A, 10 such sets of barriers were constructed during July, 1942. In experiment B, 8 additional sets of barriers with the 7 inferior oils eliminated were constructed to obtain additional data 24 and 48 hours after treatment.

In taking data three observers with stop watches lined up behind the experimental barriers and counted the bugs that crossed each barrier in one minute. Each record therefore gave three individual counts of the number of bugs crossing a 40-inch barrier and was recorded as one reading (number of bugs crossing 10-foot barrier per minute). The use of three observers, two of whom had no knowledge of the order of treatments eliminated the possibility of individual bias creeping into the data.

A wide variety of climatic and soil conditions was represented in the 1942 tests. Five sets of barriers were constructed on hot dry soil, three on wet soil after a rain and two on cool dry soil. On two occasions barriers constructed on dry soil were subjected to a moderate rain during the night before the 24-hour reading.

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[2] Now at Urbana, Illinois.

Table 1.—Average number of bugs crossing 10 feet of line barrier per minute.

Material Tested	Hours after Treatment				
	Experiment A			Experiment B	
	2	6	24	24	48
(20) Chloro-2-phenylphenol 20%	7.6	10.6	24.0	15.4	19.6
(5) Coal tar creosote (A)	19.0	12.8	35.6	28.8	28.4
(4) Wood creosote (Settled tar)	21.6	15.0	38.8	30.8	34.2
(12) Wood creosote (XXX Refined)	11.4	18.2	34.4	32.6	41.4
(15) Wood creosote (XXX Refined)	9.0	18.8	30.8	33.6	37.2
(19) Chloro-2-phenylphenol 10%	15.2	26.0	51.6*	41.0	49.4*
(13) Lignite creosote	14.8	21.0	47.6	42.4	38.0
(14) Wood creosote (refined)	16.2	26.6	46.4	55.4	58.0*
(11) Wood creosote (Vacuum acetic tar)	23.0	23.0	53.2*	72.4*	50.4*
(6) Coal tar creosote (B)	29.0	27.8	52.4*	76.2*	50.6*
(3) Wood creosote (Vacuum acetic tar)	14.8	25.8	71.4*	98.8*	50.2*
(1) Wood creosote (Settled tar)	44.8*	25.6	75.4*	100.4*	63.4*
(2) Wood creosote (Settled tar)	39.4*	45.4*	88.2*	166.4*	89.8*
(16) Pine tar (refined)	47.4*	42.2*	120.4*		
(7) Naphthalene drain oil	11.6	46.2*	121.2*		
(10) Water gas tar (refined)	64.5*	76.4*	130.2*		
(9) Pine tar (crude)	70.4*	52.6*	173.8*		
(8) Water gas tar	88.2*	443.0*	447.2*		
(18) Road oil	205.8*	403.4*	694.6*		
(17) Crank case oil	390.1*	672.8*	957.3*		
Significant difference	13.5	16.7	14.6	30.6	20.6

* Significantly different from creosote (5).

All of the original data were submitted to the Statistical Service Laboratory for study. The seven inferior oils were eliminated by eye inspection and the rest of the data subjected to analysis of variance treatment. By using the values obtained for significant differences ($P=0.05$) it is possible to compare any two treatments in the series for significance. All are compared with coal tar creosote A, which was the best of the creosotes tested.

In addition to counting the bugs crossing the line, the regular staff and six visiting entomologists judged the barriers and scored them. (*i.e.* rated them in order of effectiveness, the best as number 1 down to the poorest as number 20).

The materials tested were as follows:

	Material
(1)	Wood creosote (settled tar)
(2)	Wood creosote (settled tar)
(3)	Wood creosote (vacuum acetic)
(4)	Wood creosote (settled tar)
(5)	Coal tar creosote (A)
(6)	Coal tar creosote (B)
(7)	Naphthalene drain oil
(8)	Water gas tar (crude)
(9)	Pine tar (crude)
(10)	Water gas tar; (refined)
(11)	Wood creosote (vacuum acetic tar)
(12)	Wood creosote (XXX creosote)
(13)	Lignite creosote
(14)	Wood creosote (refined)
(15)	Wood creosote (XXX creosote (1941))
(16)	Pine tar (refined)
(17)	Crank case oil (used)
(18)	Road oil
(19)	Chloro-2-phenylphenol (10%) in fuel oil (90%)
(20)	Chloro-2-phenylphenol (20%) in fuel oil (80%)

EXPERIMENTAL DATA.—Field tests in 1941 seemed to show that there was a considerable difference in the performance of creosote from different sources. Since creosote was of necessity the standard of comparison to be used in this search for substitutes, samples taken from 5 different tank cars (all purchased and delivered under the same specifications) were tested in experimental barriers. The best (A) and the poorest (B) were selected for inclusion in the experimental tests (items 5 and 6 in list of materials tested).

All of the data taken on the number of bugs crossing barrier lines of the 20 oils under test are summarized and the significance of the data indicated in table 1. The treatments are listed in the order of their apparent effectiveness in the 24 hours readings of experiment B. All of the wood and coal tar creosote derivatives were definitely better than pine tars, road oils and water gas drips. Treatment 20 (20 per cent chloro-2-phenylphenol in fuel oil) appears to be a better repellent than the best creosote (No. 5) but the difference is not significant. Four of the wood creosotes (treatments 4, 12, 15 and 14) and lignite creosote (13) appear to be about as good as the best coal tar creosote (5) and most of them are significantly better than the poorer creosote (6). Three of the wood creosotes (11, 3 and 1), which are significantly poorer than creosote (5) are about equal to or at least not significantly poorer than creosote (6). The composite rating of all observers who rated the experimental barriers is given in table 2. Here again it should be noted that most of the wood creosote samples rated high and compared favorably with the standard coal tar creosote (A).

DISCUSSION.—Of the 8 samples of wood creosote tested 3 were good, 3 poor and 2 intermediate, but their degree of effectiveness in chinch bug barriers could not be correlated with any of the physical

Table 2.—Composite rating of all observers who rated experimental barriers.[1]

	Hours after Treatment				
	Experiment A			Experiment B	
Material Tested	2	6	24	24	48
(20) Chloro-2-phenylphenol 20%	2	1	1	1	1
(5) Coal tar creosote (A)	7	2	4	2	2
(4) Wood creosote	11	4	3	3	4
(12) Wood creosote	4	3	5	4	3
(15) Wood creosote	3	5	2	5	5
(19) Chloro-2-phenylphenol 10%	8	7	9	7	8
(13) Lignite creosote	5	6	7	6	6
(14) Wood creosote	10	10	6	8	11
(11) Wood creosote	8	9	10	10	10
(6) Coal tar creosote (B)	12	12	8	11	7
(3) Wood creosote	6	8	12	9	9
(1) Wood creosote	13	11	11	12	12
(2) Wood creosote	14	13	14	13	13
(16) Pine tar refined	15	14	15		
(7) Naphthalene drain oil	1	16	16		
(10) Water gas tar refined	17	17	17		
(9) Pine tar crude	16	15	13		
(8) Water gas tar	18	18	18		
(18) Road oil	19	19	19		
(17) Crank case oil	20	20	20		

[1] All ratings by nine individuals (28 in all) were averaged and then arrayed to give the final rating.

properties set forth in the usual specifications. One can only conclude, therefore, that although samples of wood creosote vary greatly in physical properties and in their value as repellents when used in chinch bug barrier construction, the value of a wood creosote seems to depend upon the chemical composition of the oil and this may or may not be correlated with such physical properties as specific gravity or boiling range.

Until additional information is obtained, it is not possible to write specifications for a wood creosote that would be acceptable for use in chinch bug barrier construction, and be sure it would eliminate inferior materials. This is not too surprising when we consider the parallel situation in the case of coal tar creosote. When samples taken from five shipments of creosote purchased under the same specifications were tested considerable variation was evident and the results obtained for the best and poorest samples were significantly different.

It is worthy of note that all of the wood creosotes tested were definitely better than pine tar, gas drip and road oil.

Several of the highly volatile oils, naphthalene drain oil in particular, were very effective when fresh (Tables 1 & 2) but they dropped to lower positions in the table at the 6 and 24 hour readings.

Weather conditions have an important effect upon the tests of any particular day. Heavy viscous oils tend to show up much better on cool days, particularly when they are applied upon moist soil. On the other hand, when applied on hot, dry, dusty days the surface of these heavy oils soon become glazed or crusted. Such lines become perfectly worthless in a few hours.

The spectacular results obtained with chloro-2-phenylphenol 20 per cent in fuel oil should encourage further study of this material and related compounds in readily available diluents.—2-25-44.

Chloropicrin Treatment of Bulk Potting Soil for Japanese Beetle Control

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Chloropicrin for treatment of bulk potting soil in rough wooden bins is employed extensively by plantsmen as a means of reducing the population of weeds and certain soil micro-organisms. In typical commercial application, this chemical is injected to a depth of 2 to 6 inches at the center of each square foot of surface in a layer of moist screened or shredded soil 1 foot deep. The injections are doubled around the bin edges, and spaced 6 inches out from the wall and lineally every 6 inches. Immediately following treatment the surface of the soil is wet to a depth of 1 to 2 inches and covered with canvas or paper, which is left undisturbed for 5 to 10 days.

There appears to be no well-established series of dosage-temperature rates. The minimum the writer has encountered is 4.5 milliliters per injection at 50° F. and 3.5 milliliters at 60°, or approximately 8 and 5 ounces per cubic yard of soil. These dosages are equivalent to 18 and 12 pounds per 1000 cubic feet, whereas the usual dosage for fumigation in insect control in rooms or vaults, on the other hand, probably never exceeds 3 pounds with 8 to 12 hours' exposure.

In three tests with 1-foot depths of moist, screened soil in bins in a commercial establishment, Japanese beetle grubs were used as test insects to determine specifically the applicability of chloropicrin to disinfestation treatments in compliance with Japanese beetle quarantine regulations. These tests may be summarized as follows:

(1) Soil treated at 68° F. at the rate of 3.5 milliliters per square foot of surface was infested with 25 caged grubs 30 hours after treatment. The cages were removed 17 hours later, and on the following day all grubs were dead. The mortality in untreated soil was zero.

(2) Soil treated at 57° F. at the rate of 3.5 milliliters per square foot was infested in advance with a total of 98 grubs in 28 cages. The grubs in 4 cages that were removed after 18 hours were all dead on the following day. In the remaining cages, which were removed after 5 days, the grubs were all dead when taken from the soil 1 day later. The mortality in untreated soil was 2.3 per cent.

(3) Soil previously infested with 337 grubs in 23 cages was treated at 50° F. at the rate of 4.5 milliliters per square foot. The cages were removed after 5 days and all grubs were dead on examination 1 day later. The mortality in untreated soil was 4.8 per cent.

In the first two tests the soil was wet down after treatment, and in the second it was covered with canvas. In the third test the surface was not watered and was covered in part by canvas and in part by several thicknesses of newspaper.

The evidence from these three tests indicates that chloropicrin as applied for weed control is suitable for use in destroying the larvae of the Japanese beetle in bulk, binned potting soil.—3-2-44.

[1] E. Howard Phillips, of the Division of Japanese Beetle Control, assisted materially in this work.

San Jose Scale Control Experiments[1,2]

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Insecticides used in dormant or semi-dormant sprays applied to fruit trees in New York at present are largely restricted to petroleum oils and 4,6 dinitro-o-cresol and its salts. The oils have proved effective for the fruit tree leaf roller, European red mite, apple red bug and various species of scale insects. The dinitro products are used specifically to combat aphids and the eye-spotted bud moth. Data are given in this paper on the efficiency of these materials for the San Jose scale.

The tests were conducted under orchard conditions, using standard power spraying equipment to apply the treatments. Owing to the quiet air conditions prevailing at spraying time, it was possible to treat the plats in an unusually uniform and thorough manner.

An oil spray has become the standard treatment for San Jose scale wherever this pest occurs. However, evidence seems to be lacking whether chemical composition of the oil affects insecticidal efficiency

[1] Journal Paper No. 572 New York State Agricultural Experiment Station, Geneva, New York, December, 1943.
[2] Eastern Branch Program, 1943.

where this species is concerned. We have previously shown (Pearce *et al.*, 1942 and Chapman *et al.*, 1943) that paraffinic type oils are superior to other classes against several other species. A limited amount of data bearing on this question for San Jose scale are given in tables 1 and 2. This series of tests was applied at the "delayed dormant stage," *i.e.*, when the leaves of the blossom buds are exposed from a quarter to a half-inch. The oils were emulsified in the spraying machine just prior to their application using bordeaux mixture 2-4-100 as the emulsifying agent.

Table 1.—Efficiency of several types of petroleum oils.
Delayed dormant series, 1943.

Oil Number	Per Cent Oil in Spray	Mg. Oil Deposited per Sq. In. Bark Surface	Number Scales Examined	Per Cent Alive	Control Efficiency Per Cent
D1	0.5	0.28	1075	24.93	40.9
D1	1.0	0.49	1315	1.52	96.4
D1	2.0	0.95	343	0.00	100.0
A3	0.5	0.27	1479	1.35	96.8
A3	1.0	0.66	767	0.00	100.0
A1	1.0	0.57	654	0.31	99.3
D6	1.0	0.57	775	3.09	92.7
Control	—	—	1117	42.17	—

Attention is directed in particular to the results obtained with oils D1 and A3 at 0.5 per cent, noting that almost identical deposits were laid down by the two oils. These data show oil A3 to be definitely superior to D1. In other words, this is evidence that paraffinic type oils are more efficient insecticides for the San Jose scale than oils classified as naphthenic in character (Table 2) (Pearce *et al.* 1942). Comments are reserved on the results shown for the other oils in table 1 because of the fragmentary nature of the data.

Table 2.—Composition of oils tested.

	Oil Number			
	D1	D6	A1	A3
Saybolt universal viscosity at 100° F.	120.9	206.3	105.6	100.9
Gravity° API-60° F.	21.8	21.5	27.8	34.2
Density d 20°/4°	.9189	.9207	.8842	.8502
Kinematic Viscosity Index (ASTM)	−4	16	63	115
Specific Dispersion at 20° C. (Gladstone-Dale×10⁴)	129	130	128	102
Unsulfonated residue (AOAC)-per cent	62	62	66	86

Some of the results obtained with the dinitro insecticides are given in table 3. The dinitro powder used contains 40 per cent 4,6 dinitro-o-cresol with the balance inert filler and wetting agent. In *Elgetol* the toxicant is present in the form of the sodium salt of 4,6 dinitro-o-cresol, with approximately 27.5 ounces 4,6 dinitro-o-cresol claimed present, per gallon of product. So that we could study the action of this toxicant both in the form of the acid and as a salt, we adjusted the pH of the spray water where the dinitro powder was used. The spray water in this case had an original pH reading of 7.2. It was acidified by adding 5 ounces of oxalic acid per 100 gallons spray and made alkaline with hydrated lime used at an 8-ounce rate. The toxicant serves as its own indicator; the spray mixture being pale green when acid and bright orange when alkaline. The solubility of 4,6 dinitro-o-cresol in distilled water at 20° C. is approximately 0.03 per cent. While this degree of solubility is low, still it means that about 3.75 ounces of the compound will go into solution in 100 gallons of distilled water. In actual use larger amounts of the toxicant go into solution depending on the nature of the water employed in spraying. Thus, the pH, the "hardness," temperature and

Table 3.—Efficiency of 4,6 dinitro-o-cresol powder and *Elgetol*.
Dormant series, 1943.

Amount Used per 100 Gallons Water		Approximate pH of Spray Mixture	Number Scales Examined	Per Cent Alive	Control Efficiency Per Cent
Commercial product	Ounces dinitro-o-cresol				
		Dinitro-o-cresol powder			
0.5 lbs.	3.2	3.0	749	37.0	12.3
0.5	3.2	11.0	565	39.8	5.7
1	6.4	3.0	474	24.9	41.0
1	6.4	11.0	1015	30.7	27.2
1.5	9.8	3.0	758	20.8	50.7
1.5	9.8	11.0	575	27.1	35.7
2	12.8	3.0	1333	19.8	53.1
2	12.8	11.0	1116	22.8	46.0
3	19.2	3.0	970	14.4	65.8
3	19.2	11.0	665	13.7	67.5
		Elgetol			
1 qts.	6.9	—	1009	27.1	35.8
1.5	10.3	—	512	21.1	50.0
2	13.8	—	225	11.5	72.7
3	20.7	—	500	7.8	81.5
		A3 oil			
10	—	—	756	0.4	99.1
		Control			
—	—	—	1117	42.2	—

other characteristics of the water determine the amount of toxicant which will dissolve. It is probable that all of the toxicant was in solution at the concentrations tested in the present experiments where *Elgetol* was used and where lime was added to the dinitro powder in the spray tank.

The data obtained in 1943 (Table 3) show the dinitro products tested are rather ineffective against the San Jose scale when used at strengths currently advised in New York for the control of fruit aphids and the eye-spotted bud moth. *Elgetol* appears to have given somewhat better results than the powder. This cannot be attributed to a difference in deposition rate of toxicant on the tree, for our deposit analyses showed a heavier total deposit of 4,6 dinitro-o-cresol, at corresponding strengths, for the powder. The "penetrants" and other materials present in *Elgetol* probably contribute either directly or indirectly to the scalecidal action of this product.

SUMMARY AND CONCLUSIONS.—As other workers have found, the San Jose scale may be controlled with petroleum oil sprays and at rather low concentration of oil. We have evidence that paraffinic type oils are more efficient than those derived from an asphalt base and classified as being naphthenic in character. But this difference in toxicity was not revealed until the oil strength was reduced below 1 per cent. Where the oil is used at a 2 or 3 per cent concentration, which is customary at present, one would expect a high rate of kill with almost any of the oils that are now used in dormant sprays. However, our data suggest that in using a paraffinic type oil it may be possible to reduce the oil concentration to 1 per cent for San Jose control for this general area, provided an emulsifier is used that will equal or exceed bordeaux mixture or blood albumin (2 ounces per 100 gallons spray) in oil deposition rate. The dinitro insecticides proved ineffective against this species when used at a 4,6 dinitro-o-cresol content ranging from 3.2 ounces to 20.7 ounces per 100 gallons water. Considering cost and efficiency, a petroleum oil spray is obviously the preferred treatment for San Jose scale between these two classes of insecticides.—12-7-43.

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Dowfume to Kill Nematodes in Potting Soil

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Successful growth of gardenias is contingent on the control of nematodes by the use of either uninfested or sterilized soil. Since it is often difficult to obtain uninfested potting soil, it is always desirable to use sterilized soil for potting. Although the minimum dosage and exposure requirements were not established, preliminary experiments with *Dowfume Br-10*[1] proved to be of sufficient practical interest to justify this brief report.

FIG. 1.—The relative growth of gardenias in treated (left) and untreated soil (right).

The soil for the experiments was taken from a bed in which gardenias 3 to 4 feet high were growing. The roots of the gardenias showed heavy, typical nematode damage. The plants were pulled from the bed before taking the soil, and no attempt was made to remove the heavily infested roots that remained. Steel drums of 55-gallon capacity were filled with soil to within about 6 inches of the top. The soil temperature was 75° F. and the moisture 24 per cent.

Two different amounts of *Dowfume* were used to determine its effectiveness as a soil fumigant. Measured dosages of 100 and 200 cc. were divided about equally and poured into five depressions in the top of the soil. A fairly tight-fitting lid was placed on the drum and allowed to remain for a period of 90 hours. At the end of the exposure period, gardenias were potted from portions of soil from the top, middle, and bottom of the drum. The soil was not handled any more than was necessary for potting, and no time was allowed for airing. Plants potted in untreated soil were used as checks.

Following a 6-month period of observation, no nematodes could be found in the roots of gardenias grown in treated soil, whereas they were easily found in the roots of plants grown in untreated soil. Furthermore, the grass and weed seed present in the soil were killed by the fumigant, and the gardenias made much more rapid growth in the treated soil (Fig. 1). The treatment with 100 cc. per drum appeared to be as effective as the higher dosage. At $2.35 per gallon, the cost of the 100-cubic centimeter dosage was approximately 1 cent per cubic foot of soil. A nurseryman, who cooperated in this work, potted 14,000 gardenias in fumigated soil, getting satisfactory results from the standpoint of both nematodes and weed control.—1-24-44.

[1] *Dowfume Br-10*, supplied by Dow Chemical Company. According to the manufacturer's label, this material is composed of methyl bromide 12.2 per cent, carbon tetrachloride 26.2 per cent, and ethylene dichloride 61.6 per cent.

Tomato Hornworm Control[1]

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Prior to 1942 the tomato growers in Tidewater Virginia relied largely on calcium arsenate to control hornworms, *Protoparce sexta* (Johanssen) and *P. quinquemaculata* (Haworth). However, when this material became temporarily unavailable in 1942, the question arose as to what would be the best substitute. In 1938 Michelbacher & Essig reported that both undiluted calcium arsenate, and a 50 per cent lead arsenate dust were more effective in controlling hornworms than either 40 per cent Cryolite, 40 per cent barium fluosilicate or 40 per cent sodium fluosilicate, even when the last 3 named were used at or nearly double the dosage of the arsenicals. In 1943, Wilcox and Elmore reported that regular applications of cryolite would normally give satisfactory control, but that in cases of severe infestations it might be necessary to use calcium arsenate. They suggested dosages of 40 pounds of dust per acre for large plants.

During August of 1943, an experiment was conducted in a heavily infested tomato field to compare the effectiveness of several of these and other dusts. Since the plants were so large that they were overlapping between the rows, the grower did not want to use the power duster. Consequently, the dusts were applied with a rotary hand duster, going down one side and coming back on the other side of the row. Each treatment was applied in randomized order to 3 row plots, replicated 3 times. The plots were about 50 feet long and were so arranged that each treatment and a check plot occurred only once in each of 3 blocks or tiers.

The dusts used and the results obtained are given in table 1. General observations at the end of 24 hours indicated that calcium arsenate gave a quicker kill than any of the other dusts tested. However, since many of the worms were sick at this time, it was decided to wait until 72 hours after the dusts had been applied before making counts of the number of dead and living worms. By that time the untreated check plants and many of those treated with phthalonitrile were nearly defoliated, and many of the worms had either completed their growth and crawled into the ground to pupate, or had moved on in search of better food. This accounts for the smaller number of worms actually found on the plants in these plots.

Table 1.—Results of dusting tomatoes for the control of hornworms as measured by a count of the number of worms on and under 30 plants 72 hours after treatment.

Dusts Used	Pounds per Acre	Total Number of Worms	Per Cent Dead
Krytox	48	290	88.6
Cryolite	31	249	87.4
Calcium arsenate	44	271	87.1
Calcium arsenate 40% Paris green 10% Hydrated lime 50%	44	210	71.9
Phthalonitrile 25%	48	133	37.6
Check		69	8.7
Difference required for significance at odds of 19 to 1			12.9

[1] Eastern Branch Program, 1943.

The cryolite was so heavy that it did not dust very well with the hand duster. Nevertheless, even at a lower dosage per acre, it gave practically the same kill as did the *Krytox* (a mixture of 80 per cent cryolite and 20 per cent sulfur) and the calcium arsenate. Practically all of the living worms remaining on the plants treated with these three materials were found on parts of the plants that were not well covered with dust. The calcium arsenate—paris green—hydrated lime mixture was not quite as good as the calcium arsenate and the cryolite dusts, while the 25 per cent phthalonitrile dust gave decidedly the poorest kill. Many worms were still feeding on parts of the plants that had been heavily dusted with phthalontrile.—1-27-44.

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Control of the Long-tailed Mealybug on Avocados by Hymenopterous Parasites

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Prior to 1942, the long-tailed mealybug, *Pseudococcus longispinus* (Targ.), was one of the worst pests of the avocado in San Diego County, California. In 1939, the County Agricultural Commissioner called the writer's attention to the fact that the biological control of this mealybug was highly desirable, particularly since no satisfactory commercial treatment had ever been developed.

A survey of the infested orchards in the vicinity of Carlsbad showed a heavy population of mealybug accompanied by a black condition of the foliage resulting from the growth of sooty-mold on the mealybug excrement. Only a slight amount of parasitization was observable and this was caused by the chalcid *Coccophagus gurneyi* Comp.

There was no evidence of the work of the two species of long-tailed mealybug parasites which had been liberated by the Division of Beneficial Insect Investigations, California Agricultural Experiment Station, five years earlier on dracena in Balboa Park, 30 miles to the southwest, and on citrus at Downey, 70 miles to the northward (Flanders 1940). Wide host-free areas between these points probably retarded the spread of the parasites. In Balboa Park, however, *Tetracnemus peregrinus* Comp. was established and satisfactorily controlled the mealybug on dracenas; and at Downey, *Anarhopus sydneyensis* Timb. was well established on citrus. Local outbreaks of *Pseudococcus longispinus* on citrus have been controlled by *A. sydneyensis*. It was obvious that if the avocado tree proved to be suitable as a habitat for the adult parasites of these two species, they should eliminate the mealybug as a pest.

In the spring of 1941, therefore, collecting crews were sent out from the San Diego County Agricultural Commissioner's office to the areas where these parasites were known to be established. Sufficient

parasitized material was obtained to establish both species of parasites in the Carlsbad area. As a result, mealybugs parasitized by both species were recovered in December 1941.

A year and a half after the liberation of *Tetracnemus peregrinus* and *Anarhopus sydneyensis*, it was difficult to find an unparasitized mealybug in avocado orchards.

In December, 1943, the San Diego County Agricultural Commissioner, Dean Palmer, in a statement to the writer, credited these parasites with holding the long-tailed mealybug in check to a point where it is doing little or no commercial damage to avocado trees in orchards that had been heavily infested for years previously.

Prior to the establishment of the parasites, a large portion of the *Cryptolaemus montrouzieri* production by the county insectary was released in the avocado orchards. *Cryptolaemus*, however, was incapable of satisfactorily controlling a mealybug like *Pseudococcus longispinus*, which does not produce egg masses.

The work of *Tetracnemus peregrinus* and *Anarhopus sydneyensis* not only has caused a reduction in operation expenses of the insectary but has greatly facilitated the top-working of avocado trees. The paper sacks placed over the grafts to protect them from sun and wind afforded a perfect habitat for the mealybug. *Cryptolaemus* larvae seemed to avoid entering these sacks and would not stay there even when placed in sacks in which heavy infestations of mealybug occurred. The parasites, however, have effectively controlled the mealybugs on the grafts, particularly when the sacks are perforated so that the parasite could move freely in and out.

The biological control of the long-tailed mealybug on avocados appears to be a complete success.—1-14-44.

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Toxicity of Sodium Fluosilicate to Livestock, Poultry, and Game

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At the suggestion of the authors Dr. Howard Welch, Veterinary Science Department, Montana State College, and Dr. Edward Records, Department of Veterinary Science, University of Nevada, conducted experiments during 1939, 1940, and 1941 to determine the toxicity of sodium fluosilicate to livestock, poultry, and game. Since the experiments were limited to comparatively few test animals, neither investigator was interested in the immediate publication of the results. The almost complete replacement of arsenicals by sodium fluosilicate in grasshopper and Mormon cricket control brought about by war conditions, however, and the development of an effective bait for Mormon crickets have emphasized the immediate need for the information obtained by Doctors Welch and Records in their preliminary experiments. The following summary of their findings was prepared from separate reports submitted to the authors by Doctors Welch and Records, who have examined and endorsed its contents and granted permission for its immediate publication.

EXPERIMENTS OF DR. HOWARD WELCH AT MONTANA STATE COLLEGE.—The Mormon cricket bait used in the experiments contained 100 pounds of bran to 4 pounds of sodium fluosilicate. The grasshopper bait used contained 100 pounds of bran to 2 quarts of liquid sodium arsenite (32 per cent arsenious oxide). In both Mormon cricket and grasshopper baits approximately 10 gallons of water is added for each 100 pounds of bran. Weights of bait used in the experiments refer to dry ingredients before water was added.

Sheep 1, weight 95 pounds: Fed wet bran, alfalfa hay, and water for 2 days. Third day offered wet bait containing 4 ounces of bran and 4.6 grams of sodium fluosilicate (approximate proportion in standard Mormon cricket bait). Consumed the equivalent of approximately 1 ounce of dry bran and refused remainder. Starved 24 hours and again refused bait. Offered 4 ounces rolled oats dusted with 4.6 grams sodium fluosilicate. Consumed approximately 1 ounce and refused remainder. Placed on pasture and remained normal.

Sheep 2, weight 146 pounds: Administered 4.6 grams of sodium fluosilicate (approximate quantity per 4 ounches of bran in standard bait) suspended in 1 pint of water, by stomach tube. Remained normal.

Sheep 3, weight 134 pounds: Administered 9.1 grams of sodium fluosilicate (quantity per 8 ounces of bran in standard bait). Remained normal..

Sheep 4, weight 148 pounds: Administered 18.2 grams of sodium fluosilicate (approximate quantity per 1 pound of bran in standard bait). Remained normal.

Sheep 5, weight 148 pounds: Administered 54.8 grams of sodium fluosilicate (approximate quantity per 3 pounds of bran in standard bait). Visibly sick in 8 hours; dead in 18 hours. Autopsy showed generalized congestion of antioner portion of digestive tract.

Sheep 6, weight 95 pounds: Administered 45.5 grams of sodium fluosilicate (approximate quantity per 2.5 pounds of bran in standard bait). Sick in 5 hours; dead in 30 hours. Autopsy showed definitely outlined oval area 10 by 15 inches on lowermost surface of rumen, dark red, as if burned by contact of the poisoning agent.

Sheep 7, weight 105 pounds: Administered 36.4 grams of sodium fluosilicate (approximate quantity per 2 pounds of bran in standard bait). Apparently normal 5 days. Refused feed on sixth day; died on seventh day. Autopsy showed necrotic area 10 by 14 inches on lowermost portion of rumen; perforation of rumen and peritonitis.

As a comparison 3 sheep were fed different quantities of grasshopper bait, as follows:

Sheep 8, weight 115 pounds: Offered wet bait containing 4 ounces of bran and 4.75 cc. of sodium arsenite solution (approximate proportion used in standard grasshopper bait). Consumed entire amount. Visibly sick in 4 hours; dead in 13 hours. No autopsy, since arsenical poisoning lesions are well known.

Sheep 9, weight 148 pounds: Offered wet bait containing 2 ounces of bran and 2.37 cc. of sodium arsenite solution. Consumed approximately 0.75 ounce and refused remainder. Remained normal.

Sheep 10, weight 95 pounds: Administered 2.37 cc. of sodium arsenite solution (quantity per 2 ounces of

bran in standard bait) in 1 pint of water through stomach tube. Salivation and dullness on second day. Apparently normal on third day, and remained normal.

Cow, Hereford, 1000 pounds, 6 years old: Fed alfalfa hay 2 days, hay plus 1 pound wet bran 2 days, hay plus 4 pounds wet bran 1 week. Cow ate wet bran readily, consuming all of it at each feeding. Starved cow 24 hours, allowing water but no feed. Offered wet bait containing 6 pounds of bran and 109.2 grams of sodium fluosilicate (approximate proportion used in standard Mormon cricket bait); ate the equivalent of 2 pounds of bran and refused the rest. Given half-feed of hay. The following morning bait was offered and refused. Again fed half-feed of hay; bait offered next morning but refused. Cow held for week and then sold. At no time in the experiment did she show any symptoms of distress.

Horse: A bay mare, 1000 pounds, 20 years old, in fair condition on pasture was offered wet bait containing 2 pounds of bran and 36.4 grams of sodium fluosilicate (approximate proportion used in standard Mormon cricket bait); ate it all. Seven hours later offered 2 pounds of Mormon cricket bait mixed with rolled oats; ate 1 pound of bait and refused remainder. Three days later offered 2 pounds of rolled oats plus 36.4 grams of sodium fluosilicate (approximate proportion used in standard bait); all consumed. Seven hours later the same quantity offered but only half eaten. When offered the following day it was refused entirely, although unpoisoned rolled oats were eaten greedily. Changing back and forth with the material in similar containers the poisoned rolled oats were refused and the unpoisoned ones eaten at each trial. Horse rested on pasture 5 days to let her forget taste or odor of sodium fluosilicate. Then offered 6 pounds of rolled oats containing 110 grams of sodium fluosilicate (approximate proportion used in standard bait); ate a half-pound and refused remainder. No disturbance of health was shown throughout the experiment.

EXPERIMENTS OF DR. EDWARD RECORDS AT UNIVERSITY OF NEVADA.—The standard Mormon cricket bait mixture of sodium fluosilicate, bran, and water, containing approximately 2.25 per cent of sodium fluosilicate, was used throughout. Weights of bait used in the experiments include both dry and wet ingredients.

Sheep, two 100-pound animals: Starved 48 hours; one animal was then offered a half-pound of bait and the other 1 pound. Both ate the bait readily without definite ill effects, although the animal which ate 1 pound showed slight diarrhea 48 hours later. Four days after the first bait feeding, the sheep having been on alfalfa hay in the meantime, bait was placed in their pens in liberal amounts. They nibbled at it occasionally but showed no particular interest in it and showed no effects from the small quantities eaten.

Horse, 2 years old: Had been maintained on dry hay and water and kept in a small paddock. Offered 3 pounds of bait; in 48 hours ate about half the material, mostly in the early part of the period. Showed no ill effects. Although this horse was normally a greedy and promiscuous animal in its feeding habits, it ate only small quantities of the bait after the initial offering.

Domesticated rabbits: Two 2300-gram rabbits were kept without food for 24 hours. Fifteen grams of bait was then offered to one rabbit and 30 grams to the other. After 48 hours without other food most of the bait was still in the feeding dishes. The rabbits were then returned to regular diet and remained normal.

Chickens: Two well-grown white leghorn fowls starved overnight and then offered 100 grams of bait. One bird ate sparingly, but the other only tasted the material. Bait left in cage 5 hours and then removed. Bait was offered the following day and in 2 days' feeding about 80 grams were consumed. Birds ate ordinary food ravenously. Both remained normal.

Ducks: Two mature Pekin ducks, starved overnight, then offered 200 grams of bait. No indications of feeding at the end of 5 hours when the bait was removed. Bait offered again the following day and in 2 days' feeding about 50 grams was consumed. Birds attacked ordinary feed ravenously as soon as offered. Both remained normal.

Quail: Four full-grown quail were held for 10 days in a large cage with brush shelter, the last 24 hours without food. They were then offered 50 grams of bait. At the end of 5 hours none of the bait had been eaten. After 48 hours' exposure about 25 grams had been consumed. The birds were then returned to ordinary feed and remained normal.

Pheasants: Two mature pheasants were caged with no food for 4 days and then offered 200 grams of bait. Fed slightly at first, but soon discontinued. About 50 grams eaten or wasted after 48-hour exposure. Ordinary food attacked vigorously when offered. Both birds remained normal.

DISCUSSION.—The experiments indicate that Mormon cricket bait containing 4 pounds of sodium fluosilicate to 100 pounds of bran is extremely distasteful to sheep, horses, cows, and rabbits, and is not readily eaten by chickens, ducks, quail, or pheasants. In no instance was enough bait eaten voluntarily to cause any ill effects. Forced feeding of sheep demonstrated that 36.4 grams of sodium fluosilicate, the quantity contained in approximately 2 pounds of bait, was sufficient to cause death. One sheep was given 18.2 grams of sodium fluosilicate, the quantity in approximately 1 pound of bait, and remained normal. Wet grasshopper bait containing 4 ounces of bran and 4.75 cc. of sodium arsenite solution fed to a sheep caused death in 13 hours. Another sheep receiving 2.37 cc. of sodium arsenite solution (quantity in wet bait containing 2 ounches of bran) through a stomach tube survived. This indicates that grasshopper bait containing liquid sodium arsenite is approximately 8 times as toxic to sheep as similar bait containing sodium fluosilicate.—1-24-44.

Effects of Nicotine Dust on the Melon Aphis and Its Natural Enemies

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During July and August, 1942, plot tests were conducted with nicotine dusts on melon aphis on cantaloupes. The work was done in bottomland fields in the Arkansas River Valley in Muskogee County, Oklahoma. All tests were made with nicotine sulfate-hydrated lime dusts applied at an approximate rate of 20 pounds per acre by a *Root Model x8 Power Duster.*

The effectiveness of dusting with drag sheets was tested in 12 replicates. In four replicates made in the absence of wind no significant increase in effectiveness was obtained by their use. In eight replicates dusting was done during periods when wind was

blowing sufficiently strong to carry the dust fog out of the field. The average percentage decrease of the aphis infestations were as follows: No sheet, 66; 30 ft. sheet, 76; 60 ft. sheet 81. In untreated plots the aphis population increased an average of seven per cent. A difference of 5.0 between averages is significant. Although the 60 ft. sheet was significantly better, the shorter one being less expensive and more easily handled is perhaps the more practical.

The effectiveness of four concentrations of nicotine dust, applied with a 60 ft. sheet, was compared in six replicates. The average percentage decrease in infestations were as follows: 1 per cent, 45; 2 per cent, 71; 3 per cent, 80; 4 per cent, 81. Untreated plots showed an average increase in population of 26 per cent. A difference of 6.4 between means is significant. The 1 per cent dust was not sufficiently effective for practical use. The results from plots treated with each of the two lower concentrations varied widely. There was little difference in effectiveness between the 3 per cent and 4 per cent dusts. Both were significantly better than the 2 per cent concentration. The lower cost and better dusting quality of the 3 per cent dust, as compared with the 4 per cent mixture, makes it the more practical concentration to use in the control of the melon aphis.

To determine the effect of the nicotine dust upon the enemies of aphis, counts were made in both treated and untreated plots, just previous to the dusting and again three days after dusting. In treated plots the percentage of curled leaves bearing enemies before and after treatment were as follows: Syrphid fly larvae, 14.1 and 15.3; ladybird beetle larvae and adults, 6.6 and 6.1; aphid lion larvae, 3.8 and 4.0; aphids parasitized by *Lysiphlebus*, 12.7 and 14.6. The corresponding changes for untreated plots were as follows: Syrphid fly larvae, 13.7 and 13.4; ladybird beetle larvae and adults, 3.8 and 4.2; aphid lion larvae, 3.2 and 4.6; aphids parasitized by *Lysiphlebus*, 9.0 and 10.0. The data show that aphis enemy populations were little affected by the dust.

Since the dusts used killed high percentages of aphids and had but little effect on their enemies, the dusting of the fields brought about distinct changes in the ratio of the number of aphid enemies to the number of aphids. This probably accounted for the excellent control obtained in most of the fields dusted including some in which comparatively low kills of aphids were obtained and likewise explains the lack of control obtained in other fields where good kills of aphids were obtained.

Forty-two of the forty-eight plots treated with either three or four per cent nicotine dust were in fields that were entirely dusted with the exception of one or two check plots. The other plots were in fields only a small portion of which were treated. Where entire fields were treated there was a sudden drop in the aphis population immediately following dusting and a gradual decline of the remaining population until practically no aphis were left. But where only a small portion of the field was treated, the aphis populations began building up again following the drop after dusting and soon were again present in injurious numbers.

It appeared that in the former case the change in the ratio of enemies and aphids were such that the enemies destroyed the aphids faster than they were able to reproduce, but that where only a small portion of the field was treated, the aphids over the field as a whole still reproduced faster than their enemies were destroying them, resulting in the dusted plots soon becoming reinfested.—3-11-44.

Technique for Studying the Residual Value of Organic Insecticides

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After spending several years testing organic chemicals as possible insecticides, it has been concluded that a type of test that measures the "residual value" of any material is one of the most important parts of the investigation. The technique of such a test will be presented here with the hope that other investigators will find it to be a useful tool in their research programs.

The Greenhouse red spider, *Tetranychus bimaculatus* because of its short life history and high biotic potential lends itself as an ideal test animal. It can be grown in mass culture with very little effort providing it is kept in a warm dry situation. For a test host plant, the Henderson Baby Lima bean has worked very successfully. The bean is grown singly in three inch flower pots, and since it is necessary to grow the plant only for the primary leaves, washed sand will serve as a supporting medium for the roots.

There are many methods of applying this test insecticide but they will not be discussed here. Suffice it is to say that one should know the amount of toxicant per unit of area that is being applied in order that the work may be duplicated. The fact that this is a test to study "residual value" should emphasize the importance of spraying all plants involving one insecticide simultaneously. These plants will be infested with a known number of test animals at ever increasing "residual periods" (period between application of insecticide and infestation with test animal). Many organic materials are quite effective when applied initially but due to their volatility or for some other reason they lose their effective principle in a few days or even a few hours.

To confine the test animals to a definite area, it is necessary to apply a ring or square of sticky barrier, twelve to fifteen square centimeters in area, on the upper surface of the leaf. It has been found that the material known commercially as *Tanglefoot* is quite suitable in that it exhibits a certain degree of repellancy. One would not expect more than 10 per cent of the adult mites to be trapped in this barrier.

In transferring the adult mites from a stock culture, there is considerable danger of injuring them. To minimize this and to lessen the time devoted to transferring, one may employ paper points (such as those used in mounting small insects). While observing the mites through a binocular and while holding the point with a forceps, the test animal may be picked up with gentle sliding motion of the point. Both may then be transferred to the tanglefoot inclosure on the test plant. The mite usually crawls to the leaf surface in a few minutes after which the point may be removed. In the event the investigator cannot wait to remove the points he should anchor them in the tanglefoot ring since during bright light or total darkness the plant leaves will be oriented vertically rather than horizontally thus increasing the possibility of the points falling from the enclosure. It has been found that five adult mites per leaf or a total of ten per plant is a good working number. These are left on the plant for 48 hours (this period is designated as the test period) at the end of which time they are removed and a mortality record taken.

Five days later, all eggs deposited in the 48 hour period will have hatched providing the insecticide has had no inhibitory action. A record at this time should reveal the number of eggs deposited, the

number of eggs hatched, nymphs able to survive the first molt and any evidence of phytotoxicity.

A few examples will bear out the contention of why such tests should be of equal interest to the insect physiologist and toxicologist. One particular material has no apparent effect on the vitality of adult mites yet they will deposit very few, if any eggs. When these same mites are transferred to an untreated plant they oviposit quite normally. Other materials have little effect on either the adults or their ability to deposit eggs yet these eggs when deposited fail to hatch. In still other cases the eggs hatch but the nymphs fail to survive the first molt.

It would seem that all of these phenomena are extremely important in any investigation; and it is not likely that they would reveal themselves in the usual direct contact or gross feeding test.—2-11-44.

Biological Control of the Potato Mealybug

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The encyrtid *Acerophagus pallidus* Timb. has been used for several years to control the mealybug, *Phenacoccus solani* Ferris, infesting potato sprouts in the insectary of the University of California Citrus Experiment Station. Infestations of *P. solani* seriously interfere with the propagation of black scale on potato sprouts. Periodic liberations of *A. pallidus* were necessary since some of the mealybugs were underground, in which position many escaped parasitization and were a source of reinfestation.

It is impractical, however, to control *Phenacoccus solani* by means of *Acerophagus pallidus* when the infested potato sprouts are being used for propagating *Pseudococcus maritimus* (Ehr.) instead of black scale. *Acerophagus pallidus* oviposits readily in *P. maritimus*, although it is not a suitable host. The presence of *P. maritimus* therefore is inimical to the reproduction of *A. pallidus*. Although oviposition in *P. maritimus* by *A. pallidus* is abortive, if frequent enough it is lethal to this mealybug so that the propagation of *P. martimus* is prevented for all practical purposes.

Hosts other than *Phenacoccus solani* known to be successfully parasitized by *Acerophagus pallidus* are *Phenacoccus gossypii* Town. and Ckll. and *Pseudococcus eriogoni* Ehr.

Glenn Finney, Superintendent of the insectary, reports that *Acerophagus pallidus* develops in all of the post-embryonic stages of *Phenacoccus solani;* solitarily in very small hosts and gregariously in larger ones. A medium-sized host yields about 12 individuals. At a temperature of about 80° F., the life cycle is 17 days.

In June, 1943, several thousand live specimens of *Acerophagus pallidus* were shipped to the Board of Commissioners of Agriculture and Forestry, Honolulu, Hawaii.—1-14-44.

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A Malaria Mosquito Survey of Southern Michigan

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Michigan, although a highly malarial state in pioneer times, is scarcely given second thought in present day discussions of malaria. It will average about 70 cases per year for the entire state, with occasional cases recorded even in the Upper Peninsula.

Several recent trends have directed greater attention to the problem. Among these are the return of military personnel invalided home because of malaria, the influx in considerable numbers of southern laborers, and congested living conditions in war-swollen industrial areas leading to the rise of trailer camps and generally poorer protection against mosquitoes. With this background, it was highly desirable to investigate the malaria mosquito fauna of the state and to determine the extent and intensity of the anopheline problem. Hence, in the summer of 1943, a mosquito survey of the southern and most populous portion of the state was carried out by the writer under the auspices of the Michigan State Department of Health and the Michigan State College. A detailed report of the survey is now in preparation as a technical bulletin from the latter institution. The present note will serve to make immediately available the general results of the season's work.

The survey extended from late July to early September and covered 4512 miles in 31 counties, all located south of a line drawn from Muskegon through Midland and Saginaw Bay. A total of 660 stations were sampled, with a recorded total of 7276 larvae and pupae, and uncounted thousands of adults, of which 4907 larvae-pupae and 951 adults were brought to the laboratory and identified.

It was already known that there were only four species of *Anopheles* to consider in Michigan: *A. quadrimaculatus, A. punctipennis, A. walkeri,* and *A. occidentalis* (= *maculipennis* of authors, in part). Only a few adults of the last-named species were taken in the area covered, at several places in Midland and Tuscola Counties near the northern limits of the survey. Practically speaking, only three species occur in the region in significant numbers.

Anopheles mosquitoes were found to be abundant and widely distributed in the area. Of the 660 stations, 624 were sampled for larvae, and of these 419 or 67.1 per cent were found to be breeding *Anopheles*. A total of 7276 larvae and pupae were recorded, an average of 17.36 per station. Adults were sampled only incidentally, but a total of 951 were actually identified. On occasion, estimates in the field ranged as high as 8000 at a single location, which was the conservative calculation for *A. quadrimaculatus* resting on the privy at a boys' camp.

One striking feature of the survey was the great abundance of *Anopheles quadrimaculatus,* the most important vector of malaria in eastern United States. It was breeding in 352 or 84 per cent of the 419 stations where *Anopheles* were found. Of the 4907 larvae brought into the laboratory and identified (the balance of the 7276 represents a field count of first-instar larvae), 3685 or 75.09 per cent proved to be *A. quadrimaculatus. A. punctipennis* and *A. walkeri* shared the remainder with 19.97 per cent and 4.94 per cent, respectively. For various reasons, it is considered unlikely that the true proportion of *A. quadrimaculatus* in nature is nearly as great as that

Nevertheless, this high percentage, and the fact that it was represented in 84 per cent of the positive stations, plus the large numbers taken in the adult survey, can only mean that it is a common and important factor in the mosquito fauna of the state. This is contrary to the belief in some quarters, that inasmuch as Michigan appears on published maps to be the northern limit of its range, it would be found here rather sparingly.

A second important fact established by the survey is that *Anopheles quadrimaculatus* in Michigan is often found in combination with the other species At over one quarter of the positive stations (110 or 26.2 per cent), there were two species of *Anopheles* breeding in the same habitat, one of them being *A. quadrimaculatus*. Rarely (6 stations), all three species were present. Expressed in terms of the 352 stations where *A. quadrimaculatus* larvae were recorded, the species was the sole anopheline in two-thirds (67.04 per cent) of the cases where it occurred, and in one-third (32.9 per cent) it was associated with either *A. punctipennis* or *A. walkeri*, or rarely both.

When the data were analyzed according to type of breeding place, a third major point was evident, at least for Michigan conditions, namely that *Anopheles quadrimaculatus* breeds in some numbers in running waters which would not ordinarily be considered suitable. Of the 419 stations where *Anopheles* were found, 286 were classified as standing water (Marshes, ponds, lake margins, old creek channels, etc.) and 133 as running water (rivers, creeks, drainage ditches, etc.). As might be expected, 91.6 per cent of the former stations produced *A. quadrimaculatus*, with an average of 11.2 identified larvae per station. Of the latter, 67.6 per cent of the stations had *A. quadrimaculatus*, with an average of 8.1 identified larvae per station. The important fact is not the smaller proportion of the second type, but the fact that so large a proportion of running water habitats did produce *A. quadrimaculatus*.

It is often stated that *Anopheles punctipennis* is likely to be found in running waters and the data show that the species occurred in 63.9 per cent of the running water habitats, but only in 16.1 per cent of standing water types. This appears to be a rather significant difference. Another angle should also be noted, however, for even though *A. punctipennis* shows strong preference for running waters still it was actually collected in fewer stations in such places than was *A. quadrimaculatus* (63.9 per cent as against 67.6 per cent for the latter).

In brief, it can only be concluded from such data that southern Michigan has a tremendous anopheline population whose significant size has not hitherto been appreciated; that *Anopheles* mosquitoes are abundant and widely distributed by virtue of the state's great extent and frequency of lakes, marshes, pond holes, etc., and the miles and miles of drainage ditches and streams of all sizes; and that *Anopheles quadrimaculatus* Say, the most dangerous malaria vector of the eastern United States, is the most important and most frequently encountered anopheline mosquito in the area. While not a cause for hysteria, it is nevertheless essential that the full import of the data be realized in a consideration of the malaria problem in relation to such matters of public health as were cited in the introduction. —2-2-44.

Observations on Nematodes Associated with White Grubs

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The observations here reported were made incidental and subsequent to attempts in Wisconsin to infest white grubs *Phyllophaga* spp., with the nematodes *Neoaplectana glaseri* Steiner and *Neoaplectana* sp., known to be parasites of the Japanese beetle, *Popillia japonica* Newm.

Some of these nematodes were introduced into field cages that had been infested with first-instar white grubs by confining June beetles in them over bluegrass sod, and others into cages that had been infested with second and third instars placed in the soil by hand. The above-mentioned species of nematodes were also introduced into soil confined with various lots of grubs placed singly in ointment tins. No nematodes identified as either of the species of *Neoaplectana* were recovered from the grubs with which they had been confined, but other species of nematodes were found in these, as well as in the check grubs in tins into which no *Neoaplectana* had been introduced. Subsequently grubs were collected from many places in the field and were kept in the original field soil. Almost without exception these grubs were observed to be infested with nematodes.

Apparently nematodes of more than one species were present in some of the grubs examined, but those most abundant were of one kind, which will be referred to hereafter as the "native species." An identification made from samples sent to E. E. McCoy was to the effect that a species of *Diplogaster* was present. In the writer's opinion it was the native species which was so determined. Although probably millions of nematodes have been observed in the course of our dissections and rearings, relatively few of them were saved for determination, hence it is obvious that no positive statement can be made as to the species with which we were dealing.

A small larval stage of the native species is obviously the infective stage. Considerable difficulty was encountered in determining how these nematodes entered the living grubs but, as the study progressed, it became apparent that most of them at first were confined to the cephalic region, being rather loosely distributed in the tissues at the bases of the mandibles and other mouth parts. Most of them remained in this region until after the grub had died. The infective form was also found at times loosely attached to the body of the grub but more frequently among the setae on the underside of the epipharynx. This habit of congregating around and entering the tissues at the base of the mouth parts suggested that these nematodes sought entry into the alimentary tract, but apparently this was not the case. In long searching only a few were found in the esophagus and anterior part of the alimentary tract. None were found in the posterior portion.

Dead grubs frequently contained many of the small infective nematodes, as well as others of medium and large size. Some of the latter were females containing the young infective forms. Sometimes the small nematodes inside the females were larger than many of those observed swimming freely outside in the dissecting liquid, thus indicating that they had grown considerably inside the female before escap-

[1] The author expresses his appreciation to Lee Seaton for assistance in field and laboratory work, and to E. E. McCoy for furnishing nematode parasites of the Japanese beetle and for suggestions and other help.

ing. The reproductive forms were not found in living grubs but appeared some time after the grub had died. They were then plainly scavengers feeding on the dead tissues.

Some of the examined grubs were left in dishes with distilled water, whether or not nematodes had been found in them; and in most cases, unless the grub had dried into a hard mass, a few nematodes issued, grew, reproduced, and, when allowed enough time, increased to enormous numbers. Unless additional food was given them, the nematodes destroyed all of the grub except the skin and the chitinous parts of the head. When most of the nematodes were removed from the dish and a fresh dead grub was placed with the remainder, another enormous population would appear within a few days.

Continued submergence of the grubs and nematodes did not hinder reproduction but on the contrary seemed to facilitate it. J. J. Davis (1919) mentions "a nematode disease" in the vicinity of Lancaster, Wis., which appeared to be prevalent in wet periods. Some of these nematodes were identified by N. A. Cobb as *Diplogaster aerivora* Cobb. This nematode was reported in 1916 to be parasitic in the heads of *Leucotermes lucifugus* and in grasshopper eggs (Merrill & Ford 1916).

From the preceding statements it is seen that the exact nature of this nematode is not well understood. Obviously it attacks the living grub, but it does not appear to be especially destructive and does not reproduce until after the grub has died, when it serves as a scavenger. There is evidence, however, that some tissue in living grubs is actually destroyed by the infective nematodes and probably this activity increases mortality among the grubs. It is certain that the nematode attacks apparently healthy grubs, thus differing from some of the scavenger mites that seem to concentrate chiefly on feeble grubs, which they devour after death.

Several reasons are apparent why these nematodes have not previously been reported as widely distributed in white grubs. The infective form is very small and difficult to distinguish from tissues of the grub, except when moving actively, and the tendency is for the nematodes to remain quiet so long as they are within the tissues. Their discovery in many of the grubs also was hindered by their concentration in the cephalic region. In the early dissections much time was devoted to examination of parts of the grub behind the head and few or no nematodes usually were found. In most cases, too, these nematodes were not found until they had become active and had left the grub; consequently it was difficult to determine exactly whence they came. It was later found that when dissected grubs were allowed to remain in water for a few hours or over night, a great many more nematodes than had been suspected of being present would leave the grub and swim about in the water. Subsequently, in searching for the source of these nematodes, we devoted our attention to the cephalic region of the grub, with the results already given.—1-6-44.

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Safened Forms of Calcium and Lead Arsenate

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During the two periods of 1927 to 1932 and 1941 to 1942 considerable work was done by the writer on the chemical, meteorological, and physiological phases of arsenical injury to plants. It is expected that the technical details of this investigation will be published later. The present article is a brief general statement of those findings having the most immediate application.

Most plants give to spray, dew, fog, and rain water deposited on their leaves an acid reaction that is decidedly buffered. This acid condition, plus continual absorption of carbon dioxide from the air and leaves by leaf-surface moisture, is the principal factor concerned in the dissolution of arsenicals and bordeaux mixture. Calcium arsenate is readily decomposed by dissolved carbon dioxide. The degree of solubility in tap or distilled water is not a measure of the degree of safeness of these chemicals. An arsenical, such as calcium arsenate, may be relatively insoluble in tap water, but may in time break down completely on the plant. The addition of lime alone did not safen arsenicals or maintain an alkaline condition on the leaf surface. A high degree of arsenical solubility on the plant is always followed by poor adhesion. One-fourth inch of rain usually removes at least 90 per cent of ordinary calcium arsenate spray and dust deposit.

Calcium Arsenate.—Dry-mixed preparations containing 1.5 to 2.7 pounds of hydrated ferrous sulfate[1] per pound of commercial calcium arsenate were many times safer and adhered several times better than ordinary calcium arsenate. Preparations containing 2.3 to 3 pounds of the sulfate per pound of calcium arsenate were noticeably safer than preparations containing less than 2 pounds of the sulfate per pound of arsenate. In most combinations the addition of lime increased injury. In some safened mixtures there was a slight reduction in insect toxicity, but this seemed to be correlated more with the proportion of lime in the mixture than with the proportion of ferrous sulfate present. All commercial calcium arsenate is a mixture of calcium arsenates having different chemical formulas. They are usually prepared by adding a dilute solution of arsenic acid to a hydrated lime suspension at a fixed temperature, and they contain an average of 77.7 per cent of actual calcium arsenate, and considerable excess calcium compounds, including 8.3 per cent of free hydrated lime. This gives an average of 22.3 per cent of non-calcium arsenate material (Nelson *et al.* 1937). In future tests samples of calcium arsenate should be used containing (1) no excess lime and (2) very small quantities of excess lime. Omission of some lime might lower the quantity of ferrous sulfate required, make a safer compound, and lessen the danger of lowering the toxicity to insects.

Lead Arsenate.—Tank-mixed sprays containing 1.6 pounds of ferrous sulfate and 0.4 pound of hydrated lime per 1 to 1.5 pounds of lead arsenate in the mixture and dry-mixed preparations containing 0.25 pound of lime and 1 to 2 pounds of ferrous sulfate per 3 pounds of lead arsenate were very adhesive, and highly safened, without loss of toxicity to in-

[1] All sulfates mentioned in this paper were of the hydrated orm.

sects. It is interesting that in the tank-mixed preparations 4 parts of ferrous sulfate were required for each part of hydrated lime in the mixture.

Three methods of mixing were employed:

1. Tank-mixed. In this method the two or three necessary ingredients were mixed in the field in a spray tank. Where lime was one ingredient it was stirred in a pail with at least four times its weight of water, and then poured into a tank partially or completedly filled with water containing the completely dissolved sulfate. The arsenical was added last while the agitator was still in motion.

2. Tank-mixed, filtered, and ground. In this method the ingredients were tank-mixed as just described, except that the quantity of water was only 5 to 10 times the total weight of dry ingredients. Neither the optimum nor the most practical ratio of dry ingredients to water has been determined. After the mixing, the water was decanted or filtered off, and the residue dried and ground into a fine powder. Although a few preparations of a pound or less have been made by this method in the laboratory, too few field tests have been made to measure their efficacy.

3. Dry-mixed. The chemicals were stirred together dry and finely ground in a ball or hammer mill, or in a *Micronizer*.[1] Micronized samples possess the most desirable physical properties and adhere best. Micronized samples were, however, only slightly safer than unmicronized ones. There is enough water in the sulfate crystals to make possible a chemical change without the addition of water. Compositions containing ferrous sulfate turned brownish to brick red. Those containing aluminum sulfate or zinc sulfate remained white. In general, tests thus far indicate that finely powdered, dry-mixed preparations are safer than tank-mixed preparations. The optimum formula or ratio of ingredients for the former method is not always the same as for the latter method. The dry ingredients should not be stirred together until just prior to grinding or micronizing.

Any lime used must be a finely powdered hydrated product with high calcium content.

Materials which the writer found to impart the greatest degree of safening to arsenicals were ferrous sulfate ($FeSO_4 \cdot 7H_2O$), aluminum sulfate ($Al_2(SO_4)_3 \cdot 18H_2O$), bordeaux mixture, and in some cases a small quantity of lime when the mixture contained certain sulfates. Adding arsenicals to bordeaux made the mixture adhere better and on most plants greatly reduced the injury. However, bordeaux mixture is toxic to some plants, notably those of the genera *Prunus* and *Amygdalus*. Aluminum sulfate, plus some lime, gave much promise as a safener and adhesive for lead arsenate and calcium arsenate in preliminary field tests. Other workers have reported that zinc sulfate, manganese sulfate, and manganese borate were of value as safeners for arsenicals.

Heating powdered samples to 160° F. for 4 hours had little to no effect on their phytotoxicity or their toxicity to insects. Safened powdered arsenicals were not adversely affected by aging for a year.

Safened calcium arsenate and lead arsenate spray residue gave a good kill of the striped oak worm, *Anisota senatoria* A. & S., larvae after 6 weeks of exposure, whereas commercial calcium arsenate thus exposed gave practically no kill.

Safened materials were successfully applied in the form of dust, dilute spray, and concentrated spray.

[1] Trade-mark of the International Pulverizing Corporation, Moorestown, N. J.

Ferrous sulfate, aluminum sulfate, and lime are cheaper than other compounds known to have some value in the preparation of safened materials. The lowest ton-lot quotation on ferrous sulfate before the present war was 1.75 cents per pound. The following price quotations per pound were obtained in February 1943:

Ferrous sulfate in 374-pound barrels (supply ample)	$0.03
Aluminum sulfate in 350-pound barrels (supply ample)	.035
Zinc sulfate in 100-pound bags (supply limited)	.065
Manganese sulfate in 100-pound bags (supply limited)	.035
Manganese borate in 100-pound bags	.21
Hydrated lime in ton lots (plentiful)	.05

Wild black cherry trees sprayed with standard calcium arsenate, 3 or 6 pounds per 100 gallons of water were, after 30 days, completely defoliated. Similar trees, sprayed with the safened calcium arsenate, 3 pounds per 100 gallons, showed foliage in excellent condition after 75 days. Peach foliage reacts similarly.

SUMMARY.—Calcium arsenate was highly safened with specific quantities of ferrous sulfate and aluminum sulfate. Lead arsenate was highly safened with these two sulfates plus a small proportion of hydrated lime. The safened arsenicals adhered remarkably well; so effectiveness was increased and the number of necessary applications was reduced.—12-2-43.

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Arsenic Content of Vegetables Grown in Soils Treated with Lead Arsenate[1]

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In the early part of 1943 considerable publicity was given to the subject of absorption of arsenic by vegetables from soils treated with lead arsenate for the control of Japanese beetle grubs, with specific reference to lawns that were to be dug up for Victory gardens. The New Jersey Agricultural Experiment Station received a great number of inquiries as to whether it was safe to use vegetables grown in such soils. Though the stand taken by the Station was, for safety's sake, to discourage growing vegetables in such areas, it was felt that more data were required to establish clearly the facts. Accordingly, a series of experiments were undertaken in this direction.

Series I.—A number of the common vegetables were grown on plots treated with 250, 500, and 1000 lbs. of lead arsenate per acre, incorporated into the surface 4 inches of soil 7 days before planting. The soil is a light Sassafrass loam on the Vegetable Research Farm of the Station.

[1] Journal Series Paper of the New Jersey Agricultural Experiment Station, Rutgers University, Departments of Spray Residue Investigations and Soil Chemistry.

[2] The authors are indebted to Prof. L. G. Schermerhorn, olericulturist and Mr. H. G. Bailey, of the Experiment Station, for their generous cooperation in the work on the Vegetable Research Farm.

Table 1 gives the results of the experiment and brings out the following facts: First, the arsenic intake by the different kinds of vegetables varies. Second, with an increased arsenic content in the soil, the intake increases. Third, there is a tendency for the tops to accumulate more arsenic than the roots.

Table 1.—Arsenic trioxide (As_2O_3) content of vegetables grown in soils treated with various quantities of lead arsenate.

Vegetable	Arsenic Trioxide in Vegetables Grown in Soil Treated With Lead arsenate per Acre		
	250 lbs.	500 lbs.	1000 lbs.
	p.p.m.	p.p.m.	p.p.m.
Lettuce	0.10	0.14	0.16
Eggplant	Trace	Trace	Trace
Tomato	Trace	Trace	Trace
Carrots	Trace	Trace	Trace
Broccoli	Trace	Trace	Trace
Baby Beet Roots	0.11	0.10	0.16
Baby Beet Tops	0.11	0.11	0.17
Peppers (seeds removed)	Trace	Trace	Trace
Snap Beans	None	Trace	Trace
Radish Tops	0.23	0.44	0.80
Radish Roots	0.035	0.23	0.29

In no instance, however, did the plants contain as much as 3.6 parts per million of As_2O_3, the arsenic tolerance prescribed by the Federal Security Agency for arsenical spray residues on fruits and vegetables shipped in interstate commerce, and U. S. Public Health Service investigations have shown that the presence of As_2O_3 in amounts no greater than the tolerance allowed in connection with spray residues, would not be detrimental to health.

The experiment showed further that lima and pea beans planted in the soils of the plots treated with lead arsenate either failed to germinate, or were killed in the early stages of growth.

Series II.—A site, which about 10 years ago, had been in orchard heavily sprayed with arsenicals, and which is now in vegetable crops, was selected for the second series of investigations. The soil is loamy sand to light sandy loam of the Sassafras series, located in the vicinity of Glassboro, southern New Jersey. The growth of vegetables on the site was not uniform; some spots supported good growth, others, poor growth. Samples of soil and vegetables from the good and poor spots were taken and analyzed for arsenic. The results are given in table 2.

Table 2.—The arsenic trioxide (As_2O_3) content of vegetable plants grown in soils containing arsenic resulting from orchard spray residues.

Sample	Arsenic Trioxide Content (Parts per Million)			
	Spots of Luxuriant Growth		Spots of Retarded Growth	
	Crop	Soil	Crop	Soil
Peppers (seeds removed)	Trace	48.0	Trace	100.0
Cabbage	None	40.0		
Peas (seed)	Trace	40.00	Trace	166.00
Empty Pod	.16		.48	
Vines	.66		.30	
Roots	.19		.33	
White Potatoes (whole)	.025	40.0	.050	88.0
Squash (whole)	.030	52.0	.045	100.0
Corn (Seed only)	None	100.0	None	108.0
Cucumbers	.021	56.00	.023	100.0
Tomatoes	Trace	40.0	—	—
Tomatoes	Trace	40.0	Trace	96.0
Onion Tops	.40	52.00	2.25	233.30
Onion Bulbs	.02		.11	
Snap Beans	.06	44.00	—	—

It is to be noted that the soil of the poor spots contained considerably more arsenic than did that of the good spots. Apparently the poor spots were those on which the trees had stood and on which heavy spray residues had accumulated. The good spots were those which had been between the rows of trees in the orchard.

As in the experiments on the Vegetable Research Farm of the Experiment Station, the plants took up more arsenic from soil of a high arsenic content than from soil lower in arsenic, but in not a single instance was the arsenic content of the plant samples above the limits set by the Government. Of the plant samples tested, the onion tops contained the highest quantity of arsenic.

Summary and Conclusions.—Arsenic added to soils, as in the case of lawns, or present in soils as a result of spray residues is absorbed by most vegetable crops in small quantities.

Arsenic absorption by individual crops growing on arsenic-treated soils was directly related to the quantity of arsenic in the soil.

The absorbed arsenic tends to accumulate in greater quantities in the tops of plants than in the roots.

The different crops vary in their absorptive capacity for arsenic. Of the vegetables tested, onion tops had the highest arsenic content, 2.25 p.p.m.

Of the vegetables tested, none contained as much as 3.6 p.p.m. arsenic trioxide, the maximum amount allowable on fruits or vegetables shipped in interstate commerce.

It would appear that there is no danger in growing vegetables on soils which have received applications of arsenic for one purpose or another. If the arsenic content of the soil is extremely high, the plants do not survive.

Arsenic residues linger for a long time in the surface few inches of soil and may cause injury to sensitive plants, such as lima beans. Deeper plowing, by mixing the arsenic throughout the lower layers of soils and thereby reducing the concentration at the surface, is a partial expedient for decreasing the danger of such injury.—1-29-44.

Further Tests of Dusts in Control of Mirids and Pentatomids[1]

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The effectiveness of combinations of arsenicals and sulphur against certain cotton feeding Miridae and Pentatomidae has been previously reported (Eyer & Medler 1942). Since these experiments, the opportunity to test further similar combinations against *Lygus oblineatus* Knight and also to compare combinations of pyrethrum, arsenicals, and sulphur against this species and the harlequin bug, *Murgantia histrionica* (Hahn) has been afforded.

Methods—Field cages of the same type as those employed in 1941 were used for confining the insects during the dusting experiments. The cages were placed over sugar beet plants which were in bloom or in the early fruiting stage. *Lygus* adults were col-

[1] The following investigation was carried on as part of a cooperative project of the New Mexico Agricultural Experiment Station and the Texas Gulf Sulphur Company.

Table 1.—Effectiveness of combinations of arsenicals and sulfur against *Lygus oblineatus*, as compared with *L. hesperus* and *Chlorochroa sayi* State College, New Mexico, 1942.

Insecticide	No. Insects Used	Per Cent Dead 24 hrs.	Per Cent Dead 72 hrs.	Per Cent Control* in 72 hrs.	Per Cent Control (96 hrs.) *L. hesperus* (1942) (for comparison)	Per Cent Control (96 hrs.) *C. sayi* (1942) (for comparison)
Series I. June 13–16						
Conditioned dusting sulphur, 97–98% S, 93–95%—325 mesh	178	65.2	93.8	93.3		
Calcium arsenate and conditioned dusting sulphur, 33–66%	251	96.0	100.0	100.0		
Paris green and conditioned dusting sulphur, 7–93%	188	92.6	99.5	99.2		
Unconditioned dusting sulphur 99% S, 98–100%—325 mesh	337	77.2	88.7	87.5	13.7	
Calcium arsenate and unconditioned dusting sulphur, 33–66%	289	93.8	97.6	97.2	63.0	49.8
Paris green and unconditioned dusting sulphur, 7–93%	361	87.0	95.3	94.7	22.2	
No treatment	189	6.9	8.5			
Series II. June 20–23						
Unconditioned dusting sulphur	302	94.4	99.0	95.0		
Calcium arsenate and unconditioned dusting sulphur, 33–66%	154	95.5	98.1	90.1	100.0	65.3
Paris green and unconditioned dusting sulphur, 7–93%	171	97.7	98.2	91.1	34.7	8.3
Sodium arsenite and unconditioned dusting sulphur, 14–86%	172	97.1	99.4	97.0	100.0	100.0
Basic copper arsenate and unconditioned dusting sulphur, 36–64%	161	87.0	95.7	78.0		
Calgreen and unconditioned dusting sulphur, 33–66%	245	94.7	96.7	83.4		
No treatment	157	70.7	80.3			
Series III. July 23–26						
Conditioned dusting sulphur	44	79.6	95.5	94.9		
Calcium arsenate and conditioned dusting sulphur, 33–66%	22	95.5	100.0	100.0		
Sodium arsenite and conditioned dusting sulphur, 86–14	43	95.4	100.0	100.0		
No treatment	37	5.4	10.8			

* Corrected against the untreated series using "Abbott's formula."

lected by sweeping sugar beet flower or seed stalks, and the *Murgantia* were collected from wild mustard. Stray nymphs occurring in the collections were first discarded and each group of adults were then caged for a period of eight hours and all dead individuals were removed before insecticides were applied. The numbers used for each test are recorded in the second vertical column of tables 1 and 2, and it will be seen that the mortality in the various untreated series was less than 10 per cent with the exception of the *Lygus* experiment of June 20 to 23 when temperatures were abnormally high. All dusts were mixed in the proportions indicated in the tables, by using a Hunter *New Lightning* rotary sifter and mixer No. 00, with the exception of the rotenone-sulphur combination which was a proprietary mixture containing 43 per cent sulphur and 0.75 per cent rotenone. The caged plant and insects were dusted through the sleeve opening of the canvas side of the cage with a rotary-fan type hand duster[2] adjusted to deliver 20 to 30 lbs. per acre. Examinations were made at the end of 24 and 72 hours and the percentages of bugs killed are recorded in columns 3 and 4 of the tables. The percentage control after 72 hours, as determined by the use of Abbot's formula, is given in the fifth column.

[2] Messinger Hand Duster, Model HJ.

Table 2.—Effectiveness of combinations of arsenicals, sulphur and *Pyrocide* against *Murgantia* and *Lygus*, State College, N. M., 1942.

Insecticide	*Murgantia histrionica* No. Insects Used	Per cent dead 24 hrs.	Per cent dead 72 hrs.	Per cent[1] control in 72 hrs.	*Lygus oblineatus* No. Insects Used	Per cent dead 24 hrs.	Per cent dead 72 hrs.	Per cent control in 72 hrs.
Series I. August 21–24					July 23–26			
Conditioned dusting sulphur (97–98% S) and calcium arsenate, 33–66%	46	28.3	37.0	35.4	22	95.5	100.0	100.0
Conditioned dusting sulphur and paris green, 7–93%	49	20.4	22.5	20.6				
Conditioned dusting sulphur and *Pyrocide* (0.25% pyrethrins)	54	77.8	79.6	79.1	58	96.6	100.0	100.0
Conditioned dusting sulphur, *Pyrocide* and calcium arsenate, 66–33%	49	67.4	73.5	72.8	21	95.2	100.0	100.0
Conditioned dusting sulphur, *Pyrocide* and paris green, 93–7%	48	93.8	95.8	95.7	49	97.9	100.0	100.0
Conditioned dusting sulphur, *Pyrocide* and sodium arsenite 93–7%					32	90.6	100.0	100.0
No treatment	42	0	2.4	—	37	5.4	10.8	—
Series II. August 28–31								
Conditioned dusting sulphur and *Pyrocide* (0.25% pyrethrins)	15	60.0	80.0	79.0				
Conditioned dusting sulphur and *Pyrocide* (0.50% pyrethrins)	20	65.0	100.0	100.0				
Conditioned dusting sulphur, *Pyrocide* (0.25% pyrethrins) and paris green, 93–7%	20	60.0	95.0	94.7				
Conditioned dusting sulphur and rotenone (43% S., 0.75 rotenone, remainder inert)	15	53.3	100.0	100.0				
No treatment	20	0	5.0	—				

[1] Corrected against the untreated series using "Abbott's formula."

Results—In the first series of tests using *Lygus oblineatus* (*i.e.*, 6/13–16) highest control was obtained with calcium arsenate in combination with conditioned or unconditioned sulphur (33–66 per cent). In the second series (6/20–23) in which results were somewhat invalidated by the occurrence of high mortalities in the control cages, due possibly to excessively high temperatures (*e.g.*, mean maxima; 102° F. on 6/20, 102° F. on 6/21, 100° F. on 6/22, and 96° F. on 6/23) slightly higher control was obtained with unconditioned dusting sulphur than with either the calcium arsenate or paris green-sulphur mixtures. The best control of this series (*i.e.*, 97 per cent) was obtained with the sodium arsenite-sulphur (14–86 per cent) mixture. In the third series when temperatures were almost the same as those which prevailed during the first series, 100 per cent control was obtained with both the calcium arsenate-sulphur and the sodium arsenite-sulphur mixtures. Some of these same combinations were tested in 1942, using *Lygus hesperus* and *Chlorochroa sayi*, and the percentages of control then obtained are listed in columns 6 and 7 of table 1 for comparison. Although not as consistently satisfactory as with *Lygus oblineatus*, both the calcium arsenate-sulphur and the sodium arsenite-sulphur combinations evidenced relatively high control.

In the experiments with *Murgantia histrionica* using combinations of pyrethrum, arsenicals and sulphur, the pyrethrum-paris green-sulphur mixture (*i.e.*, 0.25 pyrethrum added to the 7–93 per cent paris green-sulphur) produced 95.7 per cent control in the first (8/21–24) and 94.7 per cent control in the second series (8/28–31). This was exceeded however by the control (100 per cent) obtained with the rotenone-sulphur mixture and by the pyrethrum-sulphur mixture containing 0.50 per cent pyrethrins. When the same materials were tested against *Lygus oblineatus* (7/23–26) 100 per cent control was obtained with all combinations. The good kills of *Lygus* bugs obtained with mixtures of pyrethrum and sulphur and sodium arsenite and sulphur lend additional support to similarly favorable results reported by Fisher & Shull (1942) in Idaho and suggest the further testing of such combinations for field control.—11-29-43.

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Screwworm Survey in the Western Area of the United States in 1943

E. W. LAAKE, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

A severe drought in the Southwest early in 1943 resulted in the movement of several hundred thousand animals, principally cattle, to northern grazing and feeding areas 4 to 6 weeks earlier than usual. This unusually early movement of animals from screwworm-infested areas into uninfested areas, where climatic conditions were favorable for the development and spread of screwworms, created a great danger of outbreaks of this pest over a large area in which many livestock owners were unfamiliar with the ravages of the screwworms or the most efficient method for controlling them. There was further danger of a widespread screwworm outbreak later in the season as the result of the building up of a destructive population of flies in the Southwest, where there was a shortage of labor and, particularly, of materials for efficient screwworm control.

The primary object of the survey was to determine the extent and intensity of screwworm infestations in the western area of the United States and the amount of critical insecticides needed immediately for controlling this pest. However, it actually served a much broader purpose by introducing Smear 62 in northern areas where animals are only occasionally infested and where livestock owners and even extension personnel were unfamiliar with the potential danger of this pest or with the best means for controlling it.

The survey was begun on June 1, with four scouts free to travel throughout the affected areas. At that time almost all of Texas and at least the southern portions of Oklahoma, New Mexico, Arizona, and California were infested as a result of the spread through normal migration of the flies from the overwintering areas. Along the perimeter of this area the infestations were light, but heavy infestations were present in and near the overwintering areas in Texas. Owing to the limited survey staff and the importance of immediately surveying the heavily infested area, scouting in the more northern States had to be delayed pending completion of the survey in the southern area.

Later migration of the fly northward and eastward resulted in its spread to practically every county in Louisiana, Arkansas, Missouri, Kansas, Oklahoma, Texas, New Mexico, and Arizona, and into at least the southern portions of California, Nevada, Colorado, Nebraska, and probably Iowa and Illinois. Beyond that area numerous more or less isolated infestations, usually near packing houses, occurred in Nebraska, Iowa, Minnesota, Wisconsin, Illinois, and Indiana, which undoubtedly resulted from importations of infested animals. Before the survey finally reached these isolated infestations many of them had spread over entire counties or even groups of counties and had injured or destroyed animals valuable to their owners and highly essential to our war effort. The southern half of Michigan was surveyed, but no infestations were found.

The spread of this pest in 1943 was one of the greatest ever recorded in the western area of the United States. The survey revealed that infestations occurred during the season in every county in Louisiana, Arkansas, Missouri, Kansas, Oklahoma, Texas, New Mexico, and Arizona, and in 17 counties in California, 3 in Nevada, 32 in Colorado, 20 in Nebraska, 2 in South Dakota, 11 in Minnesota, 10 in Wisconsin, 42 in Iowa, 21 in Illinois, and 35 in Indiana.

The infestations in the more northern States were generally light, but heavy infestations involving one or more herds, and in a few instances entire counties, were encountered in different parts of practically every State. Further investigation of these local heavy infestations always revealed that southern animals had been imported early in the season. In the Southwestern States heavy infestations were general, particularly during the early summer, when there was a shortage of labor and of critical insecticides. The area of heavy infestation involved practically all the more heavily populated livestock counties in Texas, southern and eastern New Mexico, and western and southern Oklahoma. In that part of this area where summer precipitation favored the development of the fly, county agents reported heavy infestations until fall.

In Arizona and the southernmost counties of California the infestation was light until after the summer rains, when there was a considerable increase in screwworm cases, but no heavy general infestation developed. By the middle of November, when the survey was discontinued, only the four or possibly five southernmost coastal counties of California had become infested, whereas in the San Joaquin Valley the infestation extended at least as far north as the southern border of Sacramento County. Although the southernmost counties in the San Joaquin Valley were infested early in the season, the flies did not migrate to the northern counties of the valley until fall.

The survey accomplished its purpose well. It was highly effective in determining the extent and intensity of the infestation and provided the basis for estimating the amount of critical insecticides needed. In the more northern States some of the isolated infestations were promptly controlled or wiped out by the introduction and use of Smear 62. The program also resulted in the establishment of additional centers of manufacture of the smear and the availability of local supplies in many counties and trading centers in each of the affected States.

Considering the tremendous area covered and the relatively small cost of the program, the survey was highly profitable not only in its immediate effect of saving many animals so essential to our war effort, but in the educational work accomplished along with the major objective, which will undoubtedly yield further and probably even greater benefits from screwworm control in future years.—4-25-44.

JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 37 April, 1944 No. 2

E Pluribus Unum

In Columbus, Ohio, last December members of the Entomological Society of America and of the American Association of Economic Entomologists held a joint meeting to focus their attention on the entomological problems of the war. In effect they met as a single body of American entomologists. Prompted by this unified meeting, the writer ventures to bring to the surface thoughts, long repressed, on the unity of professional entomologists.

Since entomology exists as a discrete branch of zoology only because of its economic importance, and since no entomological knowledge can be proved to be economically sterile, one may question whether it is desirable any longer to maintain two national entomological societies, one pure and the other applied. In considering this question, let us start with the assumption that it is the purpose of all entomologists not only to satisfy their personal curiosity through the study of insects, but also to serve themselves and their fellow men as best they can. Only the latter objective calls for organization. As strength is always gained by the union of groups that are fundamentally similar in purpose, it may be presumed that the establishment of a single national entomological society is desirable, unless it can be shown that the present separation offers advantages sufficient to offset the probable gains of union.

If the separatist were to mutter his thoughts on the question to himself he might say (omitting profanity), "Why can't people let well enough alone. The two societies have been getting along fine for years and cooperating well whenever they had to work together. What would the founding fathers think about this proposed dictatorship? Besides I may never become a big shot in a single society. And I don't want to be in the same society with those so-and-sos who don't know this from that. And they would tax me for things I don't want. The proposal is outrageous, it's tyranny!"

If the unionist could hear these indignant reverberations he might say, "Brother, are you *sure* you're right? How about looking into the matter after you have cooled off? Nobody is trying to railroad you. It has merely been suggested that a union of the two national societies might be worth while for you and me and all of us, and also for the service we can render. Do you realize that some good entomologists will be going into the new WPA after the war, but that fewer will leave their profession if entomologists can put up promptly a strong, united front when the time for action comes? Or don't you care? Maybe I'm wrong, but it certainly seems to me that we ought to wake up and study this suggestion."

Like the unionist above, the writer pleads only for open-minded consideration of the question, for the overcoming of inertia that has so far prevented entomologists from getting and interpreting the facts bearing on the question. If any action is ever to be taken, the first step is to get a vote of the members of both societies on this question: "Do you or do you not approve the appointment of a joint committee to assemble facts and arguments for and against the union of the two national entomological societies?" If the majority of the members of both societies vote affirmatively, the way is open for an unprejudiced study of the question. This committee should look into all aspects of a possible merger: name, officers, committees, dues, finances, membership, publications, and organization of meetings. After study of the committee's report, the members of both societies could vote intelligently to unite or to remain separate.

Perhaps questions of membership, dues and publications would be most delicate and perplexing.

The two societies do not now have the

same views on membership. One goes in for "fellows," whereas the other welcomes anyone to full membership who can provide two signatures and five dollars. A compromise might be good for both; for example, a simple qualification for full membership based on education and professional experience. Associate membership might be provided for insecticide chemists, salesmen, manufacturers, pest control operators, students, amateurs and others who fail either in formal education or professional experience to meet the professional qualifications for full membership. In this way no one with an interest in entomology would be excluded, but professional entomologists could control their own affairs and could be distinguished by the public from those who are on the fringe of the profession.

Union of the two societies does not necessarily require merger of the Annals and the *Journal*. Study of the matter might show that it would be more economical and satisfactory to members to retain the two periodicals. The annual dues of a member might depend on whether he takes one or the other, or both.

F. L. CAMPBELL

Entomology and Soil Conservation[1]

PHILIP F. ALLAN

It is almost inevitable that any agricultural conservation program will impinge at some point on matters of interest to entomologists. Early in the history of soil conservation work biologists of the Soil Conservation Service recognized the necessity for consideration of entomological aspects in the work of the Service. There was a considerable discussion of the subject during the 1937 annual meeting of the Regional Biologists of the Service. Some in-Service informational material was prepared, the most important being a mimeographed publication for technicians of the Soil Conservation Service entitled, "Insect Problems Related to Soil Conservation" by Charles A. Dambach (1940). In the foreword of this paper Mr. Ernest G. Holt, formerly Chief of the Biology Division, stated, "During the past seven years it has become increasingly evident that soil conservation practices affect and are affected by insect populations to a very considerable extent. Entomological problems, previously unsuspected, have arisen as a result of the extensive and sometimes profound changes in land use and agricultural practice fostered by the soil conservation program. . . .

"The problems are by no means simple. They involve animal-plant relationships fundamentally complex that seem to have been rendered more so by agricultural practices. With them, as with most biological problems, snap judgment may indicate methods of procedure wholly unsound. It is, in other words, of prime importance that consideration be given to 'the whole array of bio-economic relationships . . . including not only crop pests but their parasites, predators, and other faunal or floral associates in their economic relations to the farm.' This, in turn, serves but to reemphasize the necessity of a coordinated multiple approach to agricultural problems if success is to be expected."

For their part the entomologists have been equally diligent in recognizing problems pertaining to soil conservation work. A resolution adopted at the 1936 meeting of the Association of Central States' Entomologists pointed out that widespread changes in land use and land use practices as advocated for soil conservation may result in increased danger from crop pests such as grasshoppers, chinch bugs and army worms. It was recommended that entomologists participate in planning land use adjustments to avoid continuations of the problems. As an outgrowth, in part, of this resolution the Soil Conservation Service and the Bureau of Entomology and Plant Quarantine exchanged correspondence and memoranda serving to clarify the problems.

In a paper entitled "Entomology in Relation to Conservation," JOURNAL OF ECONOMIC ENTOMOLOGY 31(1): 1, 1938, F. C. Bishopp presented the entomologists' viewpoint on the effects of various soil conservation practices on insect pests.

[1] Statement of the Biology Division, Soil Conservation Service, presented by Philip F. Allan, Assistant Chief, Biology Division, before the annual meeting of the American Association of Economic Entomologists, Columbus, Ohio, December 7, 8, and 9, 1943.

A number of other papers have been published on individual phases of the problem, notably, S. Marcovitch on "Experimental Evidence on the Value of Strip Farming as a Method for the Natural Control of Injurious Insects with Special Reference to Plant Lice," JOURNAL OF ECONOMIC ENTOMOLOGY 28: 62–70, 1935; Wilbur, Fritz and Painter on "Grasshopper Problems Associated with Strip Cropping in Western Kansas," Journal American Society of Agronomists 34: 16–29, 1941; and Spawn and McMurtrey on "Tillage for Grasshopper Control," Soil Conservation 9(2): 53–56, 1943.

It can be said, without offending anyone, that not nearly enough attention has been given to solving mutual problems either by those engaged in soil conservation work or in entomology. Valuable time is passing, during which soil conservation practices are being applied to ever-increasing acreages—more than 40,000,000 acres to date. Unfortunately, the Soil Conservation Service does not number among its technicians men trained as entomologists, nor is there much likelihood that such men will be employed. The Service does, however, have men with thorough biological training who are in a position to work toward the practical solution of divergent objectives in insect and soil erosion control. These men understand biotic relationships and, indeed, have been working for several years on the adjustment of soil conservation practices with respect to their effects upon wild plant and animal populations. We must look to trained entomologists, however, not only to call to our attention insect hazards likely to result from soil and moisture conservation practices, but also to work with us to find safeguards against insect damage while controlling erosion.

There is already at hand evidence to show that a cooperative approach yields worthwhile results. A few years ago, when the pale western cutworm was destroying wheat in the Great Plains, it was possible merely by conference for representatives of the Soil Conservation Service and the Bureau of Entomology and Plant Quarantine to work out mutually acceptable control measures. In addition, our Service was able to render some assistance to the entomologists who were carrying on field studies of this cutworm. Under a Memorandum of Understanding between the two bureaus and the Texas Agricultural Experiment Station cooperative studies have been carried out at Waco, Texas on insect damage to cotton with reference to soil conservation practices, while in the Northern Great Plains our Service is working in cooperation with the entomologists of the South Dakota Agricultural Experiment Station on grasshopper problems as related to wind erosion control.

One of the most vexing problems which has recently arisen is to find mutually acceptable recommendations in the areas infested with the white-fringed beetle. In this area, kudzu, a vigorous leguminous vine and preferred host plant of the insect, is on the other hand the most promising new plant for southern agriculture, not only in controlling gullies and reclaiming crop fields, but in actually serving as an important hay crop and in increasing yields of other crops through its value as a nitrogen and humus producer. There are already a quarter of a million acres of kudzu in the South—and many more coming. As an indication of the importance of this plant it may be pointed out that corn yields, following kudzu, have been increased as much as 300 per cent. It would be absurd to consider the abandonment of this important crop in the face of the white-fringed beetle threat. On the other hand, it is equally absurd to deny the threat of the insect, which in its own right may have a profound adverse effect on southern agriculture. The solution obviously does not lie in the entomologists saying "Don't plant kudzu," and soil conservationists saying "Plant it." So we are doing something about it. The biologists and agronomists of the Soil Conservation Service are working with the entomologists of the Federal and State agencies in an attempt to find out what needs to be done.

The danger of increasing mosquitoes and other insect pests resulting from farm pond construction has been called to our attention and as a result construction features designed to minimize the hazard have been developed and are being incorporated in the specifications for building farm ponds. Entomologists in South Carolina and Georgia are studying the effectiveness of these pond improvements.

A word should be said about another aspect of economic entomology in which the Soil Conservation Service is interested.

We have been helping farmers plan the establishment of thousands of acres of legumes, especially clovers. We are also encouraging them in bee-keeping, not only for honey-production, but for the production of seed. There are, likewise, more than 33,000,000 acres of agricultural land unsuited to the production of tilled crops, forage or timber crops. These acres often are preeminently suited for the production of wild crops. Honey and pollen plants can be grown on them—plants which will at the same time control erosion. For example, our Service for the past few years has encouraged the use of bicolor lespedeza on eroding field borders to provide a cover for the unproductive zone between woodlands and crop fields. There are indications that this plant may be important to southern beekeepers as a source of honey for carrying the bees through a low period of honey flow in the late summer. The honey is of good color and flavor, but may not be produced in surplus quantities. Strip-mines areas, gullies, streambanks and a variety of other places may be developed for bee pasturage by planting or encouraging the most useful plants.

There is available to entomologists a useful vehicle for organized effort in the control of insect pests—the soil conservation district. This is not a Federal organization; it is a local conservation group organized by and for farmers—developed through referenda. The farmers in a district prepare a program and plan of work for conservation activities upon their lands. They may call upon any organization, whether Federal, State, or private, to help them with their problems; and the majority of their programs recognize the need for attention to insect problems. It is impossible to say how much direct entomological help these districts have received, but it is likely very little. Since there are at present more than 1,000 soil conservation districts embracing better than a half billion acres of land the magnitude of this vehicle for insect control can well be appreciated. In districts, conservation agencies have the advantage of working with organized groups of farmers accustomed to thinking in terms of conservation and translating the help that they receive into application on their lands. Here is an excellent opportunity for entomologists to help farmers help themselves.

The Soil Conservation Service was pleased to note the interest shown by the Committee on Conservation of the American Association of Economic Entomologists, as reflected in their report last year, whereby positive action was taken on the insect problems arising from soil conservation activities. The Soil Conservation Service stands ready to cooperate in any way that its funds and facilities permit toward the solution of entomological problems which bear upon the successful accomplishment of soil and moisture conservation operations.

COMMITTEE ON POSTWAR PLANNING

President E. O. Essig has appointed the following men to constitute a committee to study post-war problems and opportunities in Entomology—

Mr. S. A. ROHWER—*Chairman* (Washington, D. C.)
Research

Dr. ROGER SMITH—(Kansas)
Employment and Placement

Dr. T. H. FRISON (Illinois)
Publications

Dr. C. E. MICKEL (Minnesota)
Taxonomy and Museums

Dr. F. C. Bishopp—(Washington, D. C.)
Entomology in Relation to Public Health
Control projects
Combat vectors of diseases

Prof. L. G. SMITH (Washington)
Extension

Prof. CLAY LYLE—(Mississippi)
Commercial Entomology

Dr. ROGER FRIEND—(Connecticut)
Cooperative Control Programs to Combat Agricultural Pests

Dr. R. W. LEIBY—(New York)
Insect Pest Survey

Dr. H. B. MILLS—(Montana)
Teaching

Mr. F. P. KEEN—(California)
Entomologist in Relation to Natural Resources

Dr. ARTHUR GIBSON—(Canada)
International Relations

PROCEEDINGS OF THE FIFTEENTH ANNUAL MEETING

Eastern Branch, American Association of Economic Entomologists

Philadelphia, Pa., November 18 and 19, 1943

The meeting was called to order by Chairman M. P. Jones, who, together with Hugh Glasgow, presided over the regular sessions. The program included 27 titles and these were presented over a day and a half, except for several that were withdrawn at the request of the War Department and for other reasons. A half-day session was devoted to a symposium on the insecticide situation. Various phases were covered as follows: Estimating the Needs for Various Insecticides, by S. A. Rohwer; Insecticide Supplies, by J. L. Horsfall; Allocations, by C. C. Hamilton; and New and Substitute Insecticides, by Charles E. Palm.

S. A. Rohwer spoke briefly on behalf of P. N. Annand, Chief, Bureau of Entomology and Plant Quarantine and E. N. Cory called attention to the forthcoming Columbus meetings and program of the national associations.

The Chairman, M. P. Jones, appointed the following committees:

Nominations: F. H. Lathrop, *Chairman*, T. L. Guyton, B. F. Driggers.

Auditing: H. G. Walker, *Chairman*, W. J. Haude.

Resolutions: Roger B. Friend, *Chairman*, J. A. Evans, Paul L. Rice.

The Secretary-Treasurer presented the following report, which was referred to the Auditing Committee.

Report of the Secretary-Treasurer

Over the past fourteen years the average number of members paying dues each year was 103. In New York at our 1942 meeting the number was 105. Apparently this figure appears to have become stabilized in the neighborhood of 100, despite the fact that notices are sent each year to 425, the number of members of the Association living in Eastern Branch territory.

The fifth or 1942 annual award was made to P. J. Chapman, G. W. Pearce and A. W. Avens, for their paper, "Relation of Composition to the Efficiency of Foliage or Summer-Type Petroleum Fractions," published in the April, 1943 issue of the *Journal*.

According to incomplete returns, there are at least 200 entomologists from Eastern Branch territory—regardless of membership in entomological associations—serving at present in the armed services, public health services and other fields of the war effort. This is about 30 per cent of the total number of entomologists in war services in the entire United States.

Financial Statement

Balance on hand, November 10, 1942		$1,999.72
Receipts		
Additional dues for 1943	$145.00	
Dues for 1944 to November 10, 1943.	52.00	
Receipts from *Entoma*	2,750.00	
Interest on savings account	9.60	
Total Receipts	$2,956.60	4,956.32
Disbursements		
Lantern and operator, 1942 meeting.	$46.30	
Payment to Secretary-Treasurer, for 1942	200.00	
Dues sent to American Association of Economic Entomologists	2.00	
Clerical Services, Eastern Branch	25.50	
Entoma	279.98	
Postage, Eastern Branch	35.50	
Entoma	200.00	
Printing, Programs, 1942	20.00	
Entoma	1,476.69	
Proceedings, 1942	428.57	
Expenses, Secretary-Treasurer	4.65	
Travel and supplies, *Entoma* Committee	14.74	
Awards	75.00	
Stationery, Eastern Branch	6.50	
Award Medals and engraving	40.92	
Total Disbursements	$2,856.35	
Balance on hand, November 10, 1943		$2,099.97
Distributed as follows:		
Savings Acct. No. 17424, Trenton Trust Co.	$1,069.76	
Checking Acct., Trenton Trust Co.	1,030.21	
	$2,099.97	
Entoma Balance in New Brunswick Trust Co., Nov. 8, 1943	289.69	
	$2,389.66	

Harry B. Weiss, *Secretary-Treasurer.*

The editor of *Entoma* made the following report, which was adopted by the Branch:

Report of the Editorial Committee for "Entoma"

November 1, 1942 to November 8, 1943

The publication of the 5th edition of *Entoma* was finally completed in August 1943. The publication of this edition has been somewhat difficult due to the increased duties of many members of the committee in connection with war effort. This edition was further delayed due to material and labor shortages experienced by the printer. In August 1943, 1531 copies of *Entoma* were distributed to members of the American Association of Economic Entomologists and members of the Eastern Branch. One hundred and sixty-five additional copies were distributed to libraries which were on the subscription list of the Journal of Economic Entomology. Ninety-five copies were distributed to advertisers and their agents. Since the publication of the 5th edition, 283 copies have been sold. This makes a total distribution of 2071 copies and leaves on hand approximately 400 copies for future sales.

From the financial standpoint the 5th edition of *Entoma* received excellent support from advertisers. A total of $2,772.88 was received from advertisements and paid listings. This is an increase of slightly more than $260.00 over the 4th edition. The demand for copies of the 5th edition of *Enoma* has been promising and at the present time some 283 copies have been sold. At the present time we have only $21.00 outstanding in unpaid advertisements and copies of *Entoma*. In general, we can say that we had receipts of $3,079.78 and expenditures of $1,986.57, which leaves us a balance of $1,093.21 in connection with the 5th edition of *Entoma*.

Clyde C. Hamilton, *Chairman*

REPORT OF THE COMMITTEE ON RESOLUTIONS

1. WHEREAS the Eastern Branch of the American Association of Economic Entomologists, having learned with deep regret of the death of Doctor Leonard S. McLaine.

BE IT RESOLVED that the Secretary extends its sympathy to his family and colleagues.

2. WHEREAS it is well known that the compilation and editing of *Entoma* entails much arduous labor, the members of the Eastern Branch hereby express their thanks and appreciation to the Editorial Committee and to Mr. Filmer for their work on this most excellent publication.

3. WHEREAS the services of The Bellevue-Stratford Hotel are greatly appreciated, the Secretary is hereby instructed to extent the appreciation of the Eastern Branch to the management.

J. A. EVANS
PAUL L. RICE
ROGER B. FRIEND, *Chairman.*

REPORT OF AUDITING COMMITTEE

The Auditing Committee has examined the books and report of the Secretary-Treasurer as of November 19, 1943 and has found everything in order. The Committee feels that Mr. Weiss should be congratulated on the excellent manner in which he has kept the records of the Eastern Branch of the American Association of Economic Entomologists.

W. J. HAUDE
HARRY G. WALKER, *Chairman.*

REPORT OF NOMINATING COMMITTEE

Your Committee proposes the following persons to serve as officers of the Eastern Branch of the American Association of Economic Entomologists for the coming year.

For Chairman—Hugh Glasgow
For Vice-Chairman—Harry F. Dietz
For Secretary (3 years), Charles S. Beckwith

T. L. GUYTON
B. F. DRIGGERS
F. H. LATHROP, *Chairman.*

The following were elected to affiliated membership in the Branch:

Wallace J. Majure, Box 417, Nashville, N. C.
Nellie M. Payne, 41 North St., Stamford, Conn.
Joseph N. Borglin, 215 W. 37th St., Wilmington, Del.
George B. Sleesman, 49 Curren Arcade, Norristown, Pa.
N. P Larson, Hulmeville, Pa.

The Report of the Secretary-Treasurer and the following committee reports were all adopted by the Branch, and new officers were elected for 1944.

Under Miscellaneous Business, E. N. Cory, for the purpose of obtaining continuity of judgment on the part of the judges for the annual award, moved that the incoming chairman appoint three judges, 1 for 3 years, 1 for 2 years and 1 for 1 year and such alternates as are necessary. After some discussion this motion was adopted by the Branch.

Clyde C. Hamilton resigned as Chairman of the Editorial Committee for *Entoma* and suggested that the chair appoint a committee of five to study a method of handling future issues of *Entoma* and its relation to the national association. This suggestion was put in the form of a motion by Roger B. Friend and adopted by the Branch.

Approximately 150 attended the meetings and the attendance and interest were good throughout.

The following members and guests registered during the sessions:

Adams, J. Alfred
Allen, H. W.
Alpert, Jerome
Alpert, M.
Anderson, Lauren D.
Arnold, R. B.
Badertscher, A. Edison
Beard, Raimon L.
Beckwith, Charles S.
Beinhart, E. G.
Borglin, Joseph N.
Boyd, Wm. M.
Brunton, J. G.
Buchholz, A. B.
Buettner, W. O.
Burgess, A. F.
Chada, Harvey L.
Chapman, P. J.
Chisholm, Robert D.
Clark, C. A.
Collins, D. L.
Connola, Donald P.
Cory, Ernest N.
Darley, Merrill M.
Deal, John
Decker, George C.
Denny, F. E.
Dieter, C. E.
Dietz, Harry F.
Dirks, C. O.
Ditman, L. P.
Dodge, H. H.
Donohoe, H. C.
Driggers, B. F.
Dusham, E. H.
Eddy, Brayton
Evans, J. A.
Fellton, Herman L.
Felt, E. P.
Filmer, Robert S.
Fleming, Walter E.
French, G. T.
Friend, Roger B.
Gaul, Albro T.
Gemmell, Louis G.
Gies, Russell W.
Ginsburg, J. M.
Girth, Harold B.
Glasgow, Robert D.
Gleissner, Bruce D.
Goddin, A. H.
Goodhue, Lyle D.
Granett, Philip
Grayson, James McDonald
Guy, H. G.
Guyton, Thomas L.
Hadley, C. H.
Hamilton, Clyde C.
Hammer, O. H.
Hansens, Elton J.
Haude, W. J.
Hawley, I. M.
Haynes, Harry L.
Headlee, Dr. T. J.
Heal, Ralph E.
Hodgkiss, H. E.
Horsfall, J. L.
Jennings, Cedric C.
Johnson, Conrad C.
Jones, Dittmar W.
Jones, M. P.
Joyce, Robert
Kenaga, Eugene E.
King, J. L.
Langford, George S.
Larson, N. P.
Lathrop, F. H.
Leiby, R. W.
Long, John C.
Maddrey, J. B.
Majure, Wallace J.
Marvin, Philip H.
Mason, Arthur C.
McCall, G. L.
McCoy, E. E.
McKnight, J.
Menusan, H., Jr.
Meyer, Martin T.
Mills, Alfred S.
Montgomery, John K.
Muma, Martin H.
Nelson, Franklin C.
Palm, Charles E.
Payne, Nellie M.
Pepper, B. B.
Pepper, J. O.
Perlstein, Frederick J.
Perrot, M.
Reis, Joseph
Rex, Edgar G.
Rice, Paul L.
Richards, A. Glenn, Jr.
Rohwer, S. A.
Sameth, J. Edwin
Sankowsky, N. A.
Sasscer, E. R.
Sleesman, George B.
Smith, Charles L.
Steiner, Harold M.
Straube, Harold L.
Sutton, Robert
Thomas, C. A.
Thomas, W. W.
Thompson, Friar M., Jr.
Turner, Neely
Walker, Harry G.
Wallace, Robert T.
Wean, Robert E.
Weiss, Harry B.
Weldon, George H.
Westcott, Cynthia
Whalen, Vincent I.
Wheeler, Ellsworth H.
Witherspoon, Robert
Wolfenbarger, D. O.
Woodbury, E. N.
Zappe, M. P.

HARRY B. WEISS, *Secretary.*

PROCEEDINGS OF THE EIGHTEENTH ANNUAL MEETING

COTTON STATES BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

New Orleans, Louisiana, February 1, 2, and 3, 1944

The eighteenth annual meeting of the Cotton States Branch of the American Association of Economic Entomologists was held in New Orleans, Louisiana on February 1, 2, and 3, 1944. The meeting was scheduled as the Southern War Conference on Entomology and stress was placed on the actual and potential contributions of the Southern Entomologists to the war effort. Over one hundred persons attended the sessions.

The printed program for the Southern War Conference on Entomology fostered the patriotic spirit of the meeting by having the flag of the United States on the front and two war bond slogans.

A special open conference on Extension Entomology was held on February 1st and M. P. Jones acted as Chairman. Consideration was given to the advancement of Extension Entomology in the Southern States.

Chairman O. W. Rosewall sounded the keynote of the conference when he delivered his address entitled, "The Future Needs of Entomology in the South." This was an excellent talk, visionary in character and thought stimulating.

The remainder of the conference was devoted to six major symposia and the presentation of technical papers. The symposia and the symposium leaders were as follows:—Cotton Insect Control, Leader Clay Lyle of Mississippi State College; The Control of Pests Affecting the Health and Comfort of Man and Domestic Animals, Leader John T. Creighton of the University of Florida; The Control of Pests of Field Crops and Stored Grains or Seed, Leader F. A. Fenton of the Oklahoma Agricultural and Mechanical College; Fruit Insect Control, Leader Oliver I. Snapp of the Bureau of Entomology and Plant Quarantine; Insecticides and Machinery, Leader P. D. Peterson of the Freeport Sulphur Company; and The Control of Pests of Commercial Vegetables and Victory Gardens, Leader C. O. Eddy of the Louisiana Experiment Station.

Dr. E. O. Essig of the University of California and present President of the American Association of Economic Entomologists was in attendance. He appeared formally before those in attendance and gave a splendid address on the subject, "Responsibilities of the American Association of Economic Entomologists in Connection with the War Effort." Dr. Essig outlined briefly the contributions made in the South by Southern Entomologists to the advancement of the science. He then presented a forceful outline for the future of American Entomology. The presence of Dr. Essig at the Southern War Conference on Entomology demonstrated the true value of the participation of national leaders in regional meetings. This great entomological leader was stimulating to the members by personal contacts, and the guidance that he provided during the deliberations of the officers of the Branch was invaluable.

The entire proceedings of the War Conference on Entomology will be released in mimeograph form during the month of June 1944.

BUSINESS PROCEEDINGS

The first business session was held at 5:45 P.M. Wednesday, February 2nd. Chairman O. W. Rosewall was presiding. The following were present:

C. H. Alden	Charles F. Henderson
Norman Allen	A. D. Hess
W. E. Anderson	Ray C. Hickman
L. H. Bailey	Ephriam Hixson
Ernest R. Barber	John H. Hughes
T. C. Barber	J. W. Ingram
F. J. Bartlett	Max Isbill
William D. Beck	Dwight Isely
F. C. Bishopp	M. J. Janes
Charles H. Brett	M. P. Jones
Arthur C. Brown	Carlos Kampmeier
E. K. Bynum	E. W. Laake
S. Steve Carnegie	Horace Lee
T. R. Chamberlin	Charles Lincoln
Alston Clapp, Sr.	Kent S. Littig
K. L. Cockerham	U. C. Loftin
R. C. Collins	Clay Lyle
R. P. Colmer	C. M. Meadows
John T. Creighton	W. H. Mecon
Paul DeBach	Jack Mitton
William Dickison	L. J. Padget
Heber C. Donohoe	N. D. Peets
W. A. Douglas	P. D. Peterson
N. L. Douglass	G. L. Phillips
Maynard Dowell	H. S. Rainwater
Emile B. Dubuisson	J. C. Redd
A. L. Dugas	J. H. Roberts
E. W. Dunnam	O. W. Rosewall
Thomas P. Dutsch	J. T. Sandberg
C. O. Eddy	S. W. Simmons
E. O. Essig	B. J. Smith
W. H. Ewart	C. E. Smith
K. P. Ewing	F. A. Smith
F. A. Fenton	Oliver I. Snapp
Roy F. Fritz	Thomas E. Snyder
R. C. Gaines	C. F. Stiles
A. L. Galloway	C. H. Stolley
J. B. Garrett	F. L. Thomas
C. F. Grafton	Friar M. Thompson, Jr.
O. B. Griggs	W. LeRoy Trayhor
Philip H. Harden	Robert E. Wean
W. R. Heard	Hiram C. Young

APPOINTMENT OF COMMITTEES

The following special committees were appointed:

1. Nominations:	Oliver I. Snapp, *Chairman*
	C. O. Eddy
	F. L. Thomas
2. Resolutions:	Clay Lyle, *Chairman*
	K. P. Ewing
	J. W. Ingram
3. Auditing:	Dwight Isely, *Chairman*
	R. P. Colmer
	C. E. Smith

Chairman Rosewall called for a report of the Secretary-Treasurer. The report was as follows:

REPORT OF THE SECRETARY-TREASURER

Funds Received		
May 1 1943	Amount on hand, in savings	$120.50
May 1 1943	Amount in checking account, University of Florida	166.72
May 22, 1943	Received from Secretary Ernest N. Cory, American Association of Economic Entomologists	34.43
January 1, 1944	Interest on deposit in savings department of First National Bank, Atlanta, Georgia, from January 1, 1943 to January 1, 1944	1.20
May 1, 1943–	Dues paid	
January 26, 1944	Dues 1943—3@$1.00	3.00
	Dues 1944—2@ $1.00	2.00
	Total	$327.85
Expenditures	Miscellaneous items	$ 45.41
Balance on Hand January 26, 1944		$282.44

JOHN T. CREIGHTON
Secretary-Treasurer

FINAL BUSINESS SESSION

Chairman O. W. Rosewall called for the reports of the committees.

The report of the auditing committee follows:

The auditing committee has checked the Treasurer's record and has found no error. Submitted by Dwight Isely, Chairman, R. P. Colmer, C. E. Smith.

The report of the resolutions committee was as follows:

Whereas, the eighteenth annual meeting of the Cotton States Branch of the American Association of Economic Entomologists has had a most profitable and successful conference on the Southern war problems in entomology, therefore

Be It Resolved, that our appreciation be extended to:

1. The local committee on arrangements,
2. The management of the Roosevelt Hotel,
3. To Professor E. O. Essig, President of the American Association of Economic Entomologists for his presence, his inspirational address, and other contributions to the success of this conference. We heartily endorse his suggestions for post-war development of entomology in all of its phases,
4. The representatives of the several commercial firms who have contributed much to the value of this conference by their presence and participation in the program.

Whereas, four members of the Cotton States Branch have died since our last meeting, therefore

Be It Resolved, that we express our deep feeling of regret and loss at the passing of Dillard W. Grimes, John C. Hamlin, Wilmon Newell, and Charles L. Stracener.

Whereas, many members of the Cotton States Branch are now serving in the Armed Forces of the United States in all parts of the world, therefore

Be It Resolved, that we express our regret for their absence and our appreciation for the patriotic service they are rendering.

Mr. Oliver I. Snapp offered an additional resolution from the floor. It was as follows:

Whereas, we all agree that this has been one of the very best meetings in the history of our Branch, which we feel is in no small way due to the work of our very efficient Secretary, therefore

Be It Resolved, that we express our appreciation and gratification to our Secretary, and to any others who may have had a part in the formation of this very fine program.

CLAY LYLE, *Chairman*
J. W. INGRAM
K. P. EWING

The report of the executive committee follows:

The executive committee considered the report which was presented by the special insecticide committee. A petition was formulated from this report and it has been duly presented to the Agricultural Insecticide and Fungicide Association through its Executive Secretary, L. S. Hitchner.

The Chairman referred to the executive committee a request from the Editors of Entoma for the appointment of a Southern representative for the sixth issue of Entoma. The Chairman appointed C. O. Eddy and this was duly approved by the Committee.

The question of a post-war planning committee for Southern entomology which was suggested by John T. Creighton during the symposium on pests affecting the health and comfort of man and domestic animals was carefully considered. The executive committee recommended that the incoming officers give careful consideration to the creation of such a committee.

O. W. ROSEWALL
E. W. DUNNAM
JOHN T. CREIGHTON

The nominations committee recommended the following officers for the year 1944–1945, and they were duly elected:

E. W. LAAKE, Dallas, Texas, *Chairman*
C. H. ALDEN, Atlanta, Georgia, *Vice Chairman*

The term of office of the Secretary-Treasurer has one additional year to run.

Past Chairman C. O. Eddy, F. L. Thomas, Clay Lyle, and Oliver I. Snapp escorted the new Chairman to the place of honor. The new Chairman took over the gavel at 5:32 P.M. He made brief remarks relative to the 1945 meetings and expressed appreciation for the honor bestowed upon him.

Final adjournment was proclaimed shortly thereafter.

JOHN T. CREIGHTON
Secretary-Treasurer.

President E. O. Essig desires to announce that the personnel of the Committee on Military Entomology appointed two years ago by President Weiss, will continue without change through the current year. The members of the committee are—

ERNEST N. CORY
ROBERT MATHESON
F. C. BISHOPP, *Chairman.*

Report of the Joint Committee of the American Association of Economic Entomologists and the Entomological Society of America on Coordination of Entomology with the War Effort

The Joint Committee on Coordination of Entomology with the War Effort, which has been requested by Presidents Essig and Mickel to continue in service through the current year, met at College Park, Maryland, April 7–8, 1944. The personnel of the committee remains unchanged as of December 1943. All members were present except S. A. Graham. In addition the presidents of the two entomological organizations were able to attend.

At his own urgent request, E. F. Phillips was permitted to relinquish the chairmanship and J. S. Houser was appointed to serve in that capacity.

It will be recalled that in the June, 1942, issue of the Journal of Economic Entomology a list of projects and their leaders was published. The entomologists there named were invited to compile and to disseminate the latest information available on the control of insect pests likely to interfere with the attainment of production goals in agriculture.

Because the goals set for 1944 differ somewhat from those of previous years, because it has been necessary to make some changes in the project leadership from time to time, and because additions have been made to the list of commodities concerning which additional effort is needed, it seems desirable to publish a revised project list.

The reports of the sub-committees received to date constitute a unique phase of the literature of economic entomology. In the opinion of the committee these reports should be preserved in the libraries of the leading entomological institutions; therefore, it is suggested that those who possess such reports preserve them for that purpose.

Naturally the reports have shown considerable variation as to methods of attack, effectiveness of presentation and in the stimulation to action. The ultimate purpose of the proposals made by the committee was to make information on insect control available to those persons in need of it. The last step is the most difficult. To further this end in a subsequent report, the committee requested that all project leaders send the material each had compiled to all entomologists located in those areas where it would be useful so that they in turn might assist in the dissemination of the information.

The reports of the project leaders have been issued in different forms. In at least one case the information was ready for direct distribution to producers. Usually, however, the material has been assembled in a form for use by national or regional entomologists, whose responsibility it becomes to select pertinent information from the reports of sub-committeemen and to use such means as may be at their disposal to effect its final dissemination. How this may be done is a matter to be determined by the entomologist in each locality. By reason of the foregoing sequence of events, the original committee has been enlarged by the inclusion of practically all economic entomologists; the group thus becomes a committee of the whole, with leadership so arranged that a considerable degree of coordination of effort is effected.

Projects and Leaders

Project	*1944 goal*[1]	*Leader*
Milk	102	E. M. Searls, *Madison, Wis.*
Chickens	96	
Broilers	84	O. G. Babcock, *Menard, Tex.*
Turkeys	97	
Hogs-Spring	85	W. E. Dove, *Washington, D. C.*
-Fall	91	
Horses	none	Suggested assistants:
Beef	96	E. G. Kelly, *Manhattan, Kan.*
Sheep	100	
Fabrics		Neely Turner, *New Haven, Conn.*
Peanuts	118	T. L. Bissell, *Experiment, Ga.*
Wheat	122	R. H. Painter, *Manhattan, Kan.*
Soy Beans	126	Geo. C. Decker, *Urbana, Ill.*
Cover-Crop Seeds	87	Don C. Mote, *Corvallis, Ore.*
Hay Crop Seeds	103	C. L. Fluke *Madison, Wis.*
Oats	92	F. A. Fenton, *Stillwater, Okla.*
Barley	100	
Rye	87	
Sugarcane	103	J. W. Ingram, *Houma, La.*
Hay	103	F. W. Poos, *Beltsville, Md.* for the East
		C. J. Sorenson, *Logan, Utah,* for the West
Sorghum	97	F. L. Thomas, *College Station, Tex.*
Corn	103	J. H. Bigger, *Urbana, Ill.*
		A. L. Hamner, *State College, Miss.*
Sweetcorn		L. A. Carruth, *Geneva, N. Y.*
Stored Products		J. J. Davis, *Lafayette, Ind.* and
		R. T. Cotton, *Manhattan, Kan.*
Deciduous Fruits		B. A. Porter, *Washington, D. C.*
Dried Fruit		Perez Simmons, *Fresno, Calif.*
Cotton	100	R. W. Harned, *Washington, D. C.*
Tobacco	120	W. H. White, *Washington, D. C.*
Sugar Beets	154	J. R. Douglass, *Twin Falls, Idaho*
Beans		Neale F. Howard, *Columbus, Ohio*
Green		L. G. Smith, *Pullman, Wash.* suggested
Dry	111	for the West
Canning Peas		East—Bailey B. Pepper, New Brunswick, N. J.
		West—L. G. Smith, *Pullman, Wash.*
Dry Field Peas	108	L. G. Smith, *Pullman, Wash.*
Tomatoes		A. E. Michelbacher, *Berkeley, Calif.*
		Harry G. Walker, *Norfolk, Va.*
Sweetpotatoes	118	Clay Lyle, *State College, Miss.*
Potatoes	103	East—W. A. Rawlins, *Ithaca, N. Y.*
		Central—H. D. Tate, *Lincoln, Neb.*
		West—K. W. Gray, *Corvallis, Ore.*
Farm Gardens		M. P. Jones, *Washington, D. C.*
Man		W. B. Herms, *Berkeley, Calif.*
		Associates suggested:
		W. A. Riley, *St. Paul, Minn.*
Damage to Buildings		T. E. Snyder, *New Orleans, La.*
Naval Stores and		S. A. Graham, *Ann Arbor, Mich.*, and
Forest Insects		F. C. Craighead, *Washington, D. C.*
Flaxseed	93	A. G. Ruggles, *St. Paul, Minn.*
Rice	100	Dwight Isley, *Fayetteville, Ark.*
Commercial		
Truck Crops		W. H. White, *Washington, D. C.*
Insecticides		L. S. Hitchner, *New York, N. Y.*

[1] Percentage of 1943.

Far more complete coordination of effort and cooperation among entomologists would be possible if there could be made available to all a record of the research projects under way. The committee plans to assemble this material and at a later date to publish it in the Journal of Economic Entomology.

The work of the committee, and particularly that of the sub-committees, has been severely handicapped by the discontinuance of the Insect Pest Survey—at a time when it would have served a most

useful purpose in prosecuting that phase of the war effort related to pest control. The Survey would have been of immense value for use in estimating insecticide requirements, in allocating supplies, in delineating those areas where work in insect control was most needed, and in many other ways. The committee then urges all entomologists to continue their efforts to bring about a restoration of this service and to have such increases or changes made in the Survey as will contribute to its usefulness.

An important problem of the entomological profession arises from the lack of prompt publication of useful information. Publication facilities for certain types of papers of special value in the emergency period are inadequate. To remedy this situation, the committee recommends that the Executive Committee of the American Association of Economic Entomologists make such allocations from the Permanent Fund as may be required to publish in the JOURNAL critical reviews and outlines of methods for direct utilization of entomological information applicable to the war effort, the material to be selected by the Publications Committee.

Cooperation between the entomologists of the Bureau of Entomology and Plant Quarantine, the Dominion organizations, the agricultural experiment stations and universities has been greatly improved during recent years and is now manifested throughout the Continent. A similar gratifying tendency to mutual helpfulness between public-supported institutions and private industry and corporations is to be commended. We strongly urge the furtherance and the strengthening of this important trend in all fields of entomological endeavor.

Entomologists know from sorry experience the devastation caused by the introduction of insect pests to new areas. The shipment of agricultural products to other countries is vastly increased by the war and will be still further augmented in the work of rehabilitation of war-stricken areas as they are freed. If the international effort to help stricken peoples is accomplished but is accompanied by the introduction of serious pests to new areas, our humane and good-will efforts will be largely nullified and in years to come we shall be blamed for such introductions. The committee then feels that it speaks for all entomologists in urging the utmost care in insuring inspection, fumigation, and other essential steps in making certain that agricultural products shipped to other lands do not harbor insect pests.

The war also multiplies the danger of introducing new insect pests; hence the most capable quarantine officers obtainable should be assigned in such numbers as may be necessary to the huge responsibility of safeguarding our country from the possibility.

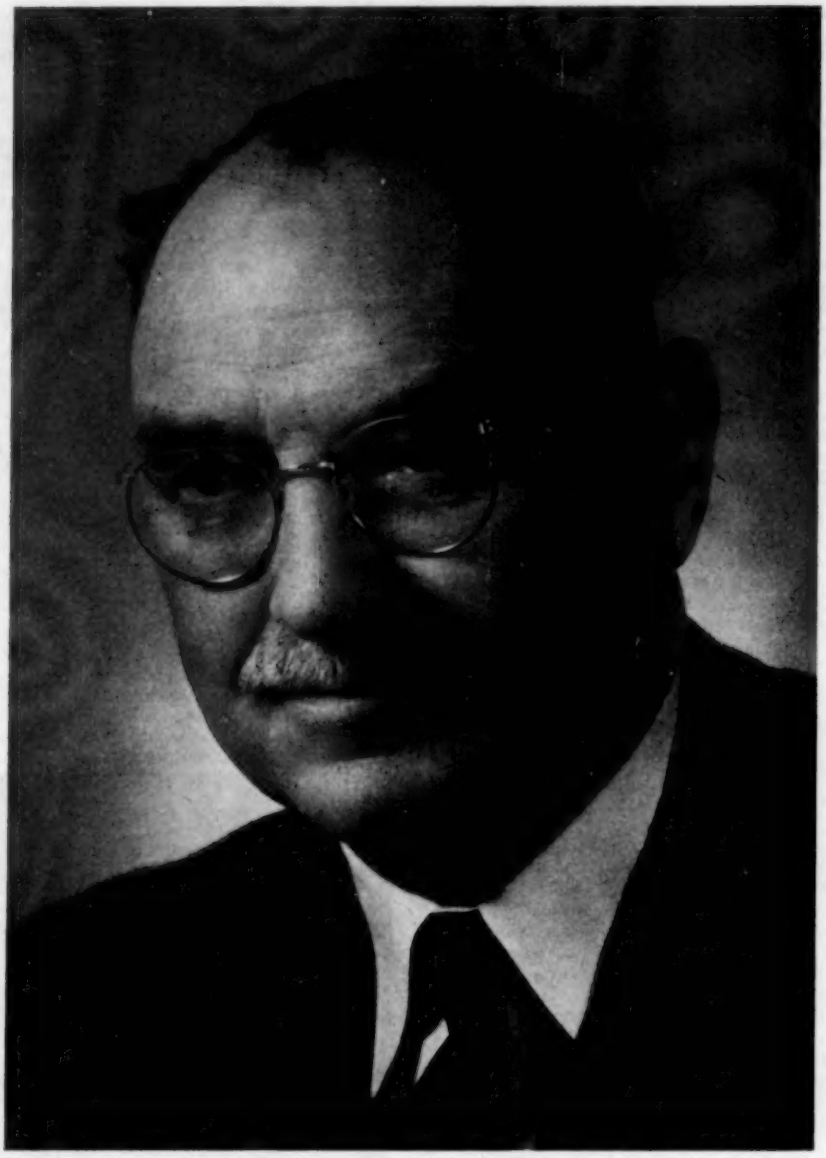
E. O. ESSIG — A. S. HOYT
C. E. MICKEL — L. M. PEAIRS
E. N. CORY — E. F. PHILLIPS
S. A. GRAHAM — P. D. SANDERS
J. S. HOUSER, *Chairman*

OBITUARIES

WILLIAM ROY WEST
1920–1944

First Lieutenant William Roy West, a member of the Association since the 1941 meeting, was killed in action during the invasion of the Marshall Islands on January 31, 1944. He was born at Ruleville, Mississippi, January 24, 1920. He was graduated from Sunflower Agricultural High School in 1937 as president and valedictorian of his class, graduating from Sunflower Junior College two years later. He was president of the Y.M.C.A. also of a literary society, played in the band and was a star athlete. He was graduated from the University of Alabama in 1941 and because of his fine scholastic record was selected as a graduate assistant in the Zoology and Entomology Department of Mississippi State College, where he served during the session of 1941–1942. He enlisted in the Marines in the summer of 1942 and in January, 1943 was commissioned a second lieutenant in the regular Marine Corps instead of the Reserves as a result of having one of the five highest grades in his class. He married Martha Hamilton Lacy of Booneville, Mississippi, on February 12, 1943, and served at Camp Pendleton, California until he went overseas in January. He was promoted to first lieutenant October 4, 1943. He was a fine student, an untiring worker, intensely interested in entomology. Lieutenant West was also a member of the Entomological Society of America, and although his career was just beginning, he would have undoubtedly made a record of splendid achievement in entomology, if he had lived. His genial, friendly personality endeared him to faculty and students alike and his death was a great, saddening shock to all who knew him.—CLAY LYLE.

William Roy West, 1920–1944



Hugh Knight, 1877-1943

Hugh Knight was born in Southampton, England, October 17, 1877, and died at Pomona, California, October 9, 1943. His first interest was in music, and at the age of eight he passed the examination of the Royal Academy of Music, London, for violin playing. At the age of fifteen he was awarded the "Honours Certificate" by the London College of Music, and a year later was granted the distinctive title of "Associate" by the same institution, with the right to append the letters "A.L.M.C."

Mr. Knight attended schools at Winchester, England, and in Switzerland and the Black Forest, Germany. His family came to the United States in 1893 and settled at San Antonio, Texas. In 1900 he married Frances Boswell Arneil of Southampton and later settled at Elsinore, California. While located there he joined the staff of the Riverside County Horticultural Commissioner's office and served as inspector from 1907 to 1919. In the latter year he became assistant in Entomology at the University of California Citrus Experiment Station, Riverside, which position he held until 1925. From 1925 to the time of his death he was connected with, or consultant for, the following concerns in the order given: California Spray Chemical Company, Emulsoids Inc., Standard Oil Company of Indiana, and Shell Development Company.

In 1931 Mr. Knight entered into an arrangement

with Pomona College, Claremont, California, whereby the college built and rented to him a small laboratory building of his own design. His research work was henceforth carried on at that place. He proved to be a useful addition to the campus of that institution and students interested in economic entomology frequently consulted with him.

Mr. Knight had the fortunate habit of qualifying himself for a larger field than the immediate duties of his particular position required. While he was an agricultural inspector he prepared for his own particular needs a scheme for the identification of insects. The attribute represented by this contribution more than any other one thing attracted him to the writer to fill a position which was then vacant. He proved to be a natural research man; he had curiosity, an active mind, and was unusually resourceful in ideas. When ramifications of his problem involved him in unfamiliar fields he was not in the least deterred—he proceeded to the self mastery of those fields. His school training was not of the kind to prepare him for the complicated problems that later he was to encounter in the complex subject of the chemistry and physics of petroleum oil sprays. His infectious enthusiasm was the driving force that kept him alert in his work, and which made him interesting to his friends.

While his investigations in the field of cyanide fumigation was of brief duration, he made important studies in that field. It was in the field of petroleum oil sprays, however, that his outstanding contributions were made. It was largely his work that resulted in putting highly refined white oils in California on a commercial basis in the early 20's by reducing the amount of the emulsifier and thus the amount of oil from 10 per cent, as first used, to 2 per cent for the California red scale. This early work attracted him to the commercial field where his painstaking research was carried on, chiefly in the field of oil sprays, for the following eighteen years. His work with particular oil-soluble emulsifiers and penetration and control agents regulating oil penetration into plant tissue may be said to have culminated in the "emulsive" type of oil spray which he developed and which is the predominant type of oil spray now used on citrus trees in California. Such an oil spray has the further merit of permitting the incorporation of certain solids such as cryolite because of the p eferential wetting of such solids by the emulsive spray oils.

The following titles, or abstracts, of some of his patents, which have been kindly furnished by Mr. Payne of the Standard Oil Company of Indiana, will indicate the extent to which Mr. Knight went into the subject of oil sprays:

Use of polar compound in white oil tree sprays; insect poison in white oil tree sprays; use of certain esters of unsaturated fatty acids in insecticidal oils; acylated alkyl esters of ricinoleic acids in spray oils; use of ester to regulate vaporization of low viscosity spray oils; use of partially esterfied polyhydroxy alcohol in spray oils; hydroxy ester of high molecular weight organic acids in spray oils, certain naphthenic acids with hydroxy ester of high molecular weight organic acid in tree spray oils; bentonite conditioner in tree spray oils of above types; glyceryl oleate and aluminum naphthenate composition in spray oils; oil soluble amine salt of fatty acid in above type of tree spray oils; certain amine salts, Bentonite, etc., in spray oils of above type.

Mr. Knight is survived by his widow, Frances B. Knight, Glendora, California, and a son, Major Hugh B. Knight, at present attached to the Commanding Officer, Army Air Field, Santa Maria, California, and two grandchildren, and his brother, L. M. Knight, Corpus Christi, Texas.

H. J. QUAYLE

EUGENE WARREN MENDENHALL
1874–1944

Eugene Warren Mendenhall, nursery inspector in the State Department of Agriculture and well known as an entomologist, died early on Friday, March 24, 1944 at his residence in Columbus, Ohio. He had been ailing for several weeks but continued his duties through Wednesday.

Born on a farm near Green Valley, Knox County, Mr. Mendenhall came to Columbus 50 years ago and for 37 years had been associated with the State Department of Agriculture. He was graduated from the college of agriculture, Ohio State University, in the class of 1898.

He was an active member of Indianola Methodist Church, the American Association for the Advancement of Science, Archaeological and Historical Society, the Entomological Society of America and, for many years, of The American Association of Economic Entomologists.

His wife, Mrs. Jessie Wetmore Mendenhall, survives him, as do also two daughters, Mrs. Stanley E. Hill, East Moline, Ill., and Miss Gertrude E. Mendenhall, of the home; two grandchildren, Lee Eugene and Warren Herbert Hill; brother, L. C. Mendenhall, of Sarasota, Fla., a sister, Mrs. B. F. Parmenter, Fredericktown, Ohio, and a step-sister, Mrs. Harker Lybarger, Mt. Vernon.